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OF THE

American Fisheries Society

FIFTY-FOURTH ANNUAL MEETING

QUEBEC, CANADA

SEPTEMBER 10, 11, 12, 1924

Periodical

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1924

U. S. DEPARTMENT OF THE INTERIOR

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U. S. GEOLOGICAL SURVEY

American Fisheries Society

ORGANIZED 1870

INCORPORATED 1910

Officers for 1924-1925

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Vice-President CHARLES O. HAYFORD, Hackettstown, N. J.
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Recording Secretary FLOYD S. YOUNG, Chicago, Ill.
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PRESIDENTS, TERMS OF SERVICE AND PLACES OF MEETING

The first meeting of the Society occurred December 20, 1870. The organization then effected continued until February, 1872, when the second meeting was held. Since that time there has been a meeting each year, as shown below. The respective presidents were elected at the meeting, at the place, and for a period shown opposite their names, but they presided at the subsequent meeting.

1.	William Clift	1870-1872	New York, N. Y.
2.	William Clift	1872-1873	Albany, N. Y.
3.	William Clift	1873-1874	New York, N. Y.
4.	Robert B. Roosevelt	1874-1875	New York, N. Y.
5.	Robert B. Roosevelt	1875-1876	New York, N. Y.
6.	Robert B. Roosevelt	1876-1877*	New York, N. Y.
7.	Robert B. Roosevelt	1877-1878	New York, N. Y.
8.	Robert B. Roosevelt	1878-1879	New York, N. Y.
9.	Robert B. Roosevelt	1879-1880	New York, N. Y.
10.	Robert B. Roosevelt	1880-1881	New York, N. Y.
11.	Robert B. Roosevelt	1881-1882	New York, N. Y.
12.	George Shepard Page	1882-1883	New York, N. Y.
13.	James Benkard	1883-1884	New York, N. Y.
14.	Theodore Lyman	1884-1885	Washington, D. C.
15.	Marshall McDonald	1885-1886	Washington, D. C.
16.	W. M. Hudson	1886-1887	Chicago, Ill.
17.	William L. May	1887-1888	Washington, D. C.
18.	John H. Bissell	1888-1889	Detroit, Mich.
19.	Eugene G. Blackford	1889-1890	Philadelphia
20.	Eugene G. Blackford	1890-1891	Put-in Bay, Ohio
21.	James A. Henshall	1891-1892	Washington, D. C.
22.	Herschel Whitaker	1892-1893	New York, N. Y.
23.	Henry C. Ford	1893-1894	Chicago, Ill.
24.	William L. May	1894-1895	Philadelphia, Pa.
25.	L. D. Huntington	1895-1896	New York, N. Y.
26.	Herschel Whitaker	1896-1897	New York, N. Y.
27.	William L. May	1897-1898	Detroit, Mich.
28.	George F. Peabody	1898-1899	Omaha, Nebr.
29.	John W. Titcomb	1899-1900	Niagara Falls, N. Y.
30.	F. B. Dickerson	1900-1901	Woods Hole, Mass.
31.	E. E. Bryant	1901-1902	Milwaukee, Wis.
32.	George M. Bowers	1902-1903	Put-in Bay, Ohio
33.	Frank N. Clark	1903-1904	Woods Hole, Mass.
34.	Henry T. Root	1904-1905	Atlantic City, N. J.
35.	C. D. Joslyn	1905-1906	White Sulphur Springs, W. Va.
36.	E. A. Birge	1906-1907	Grand Rapids, Mich.
37.	Hugh M. Smith	1907-1908	Erie, Penna.
38.	Tarleton H. Bean	1908-1909	Washington, D. C.
39.	Seymour Bower	1909-1910	Toledo, Ohio
40.	William E. Meehan	1910-1911	New York, N. Y.
41.	S. F. Fullerton	1911-1912	St. Louis, Mo.
42.	Charles H. Townsend	1912-1913	Denver, Colo.
43.	Henry B. Ward	1913-1914	Boston, Mass.
44.	Daniel B. Fearing	1914-1915	Washington, D. C.
45.	Jacob Reighard	1915-1916	San Francisco, Calif.
46.	George W. Field	1916-1917	New Orleans, La.
47.	Henry O'Malley	1917-1918	St. Paul, Minn.
48.	M. L. Alexander	1918-1919	New York, N. Y.
49.	Carlos Avery	1919-1920	Louisville, Ky.
50.	Nathan R. Buller	1920-1921	Ottawa, Canada
51.	William E. Barber	1921-1922	Allentown, Pa.
52.	Glen C. Leach	1922-1923	Madison, Wis.
53.	George C. Embody	1923-1924	Ithaca, N. Y.

*A special meeting was held at the Centennial Grounds, Philadelphia, Pa., October 6 and 7, 1876.

TABLE OF CONTENTS

List of Officers	3
Presidents	4

PART I—BUSINESS SESSIONS.

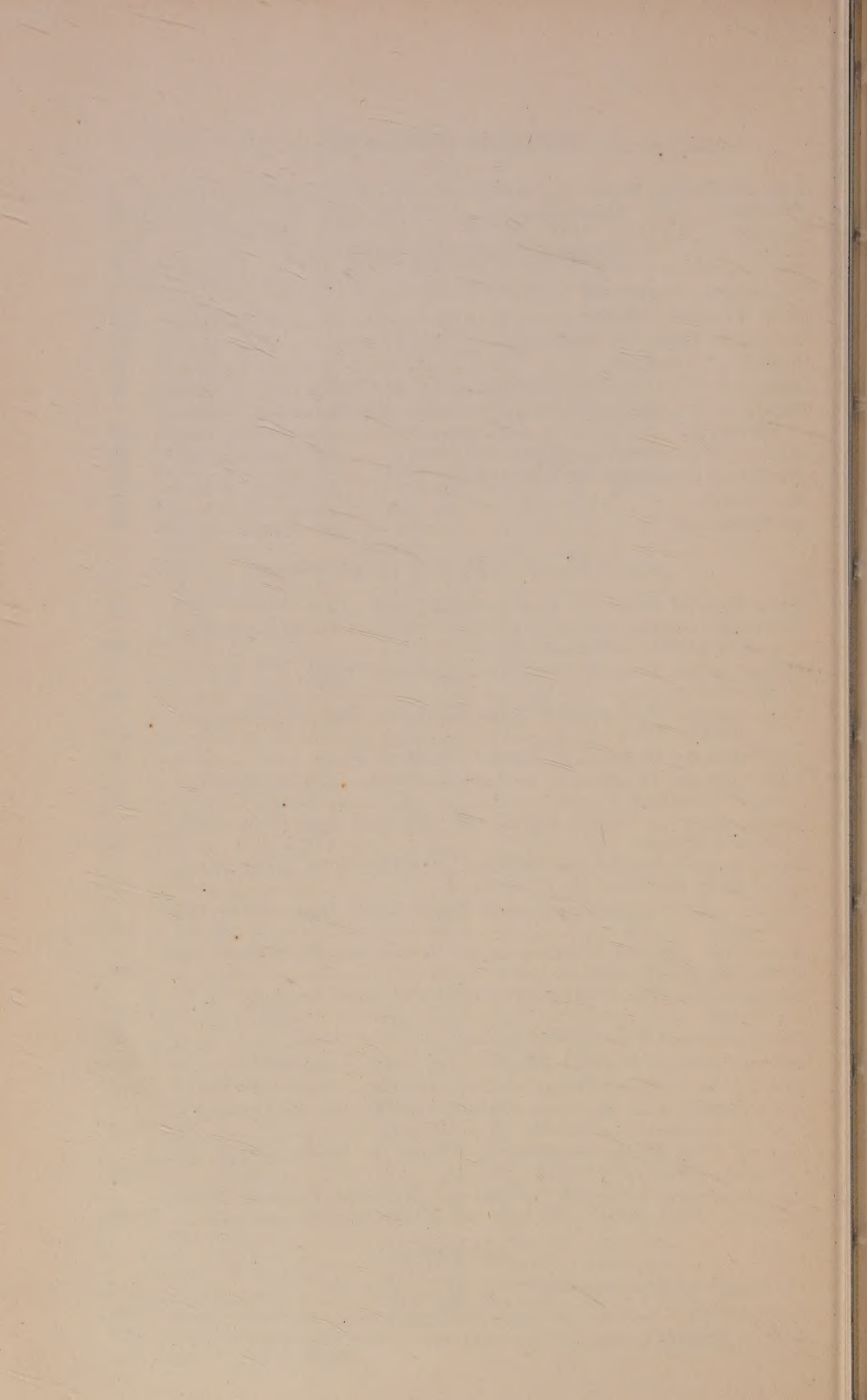
Registered Attendance	9
New Members Elected	10
Report of Executive Secretary	10
Report of Treasurer	12
Report of Vice-President, Division of Aquatic Biology and Physics	15
Report of Committee to attend President's Conference on Outdoor Recreation	17
Report of Committee on Time and Place	18
Report of Committee on Nominations	18
Resolutions	18
In Memoriam	22

PART II—PAPERS AND DISCUSSIONS.

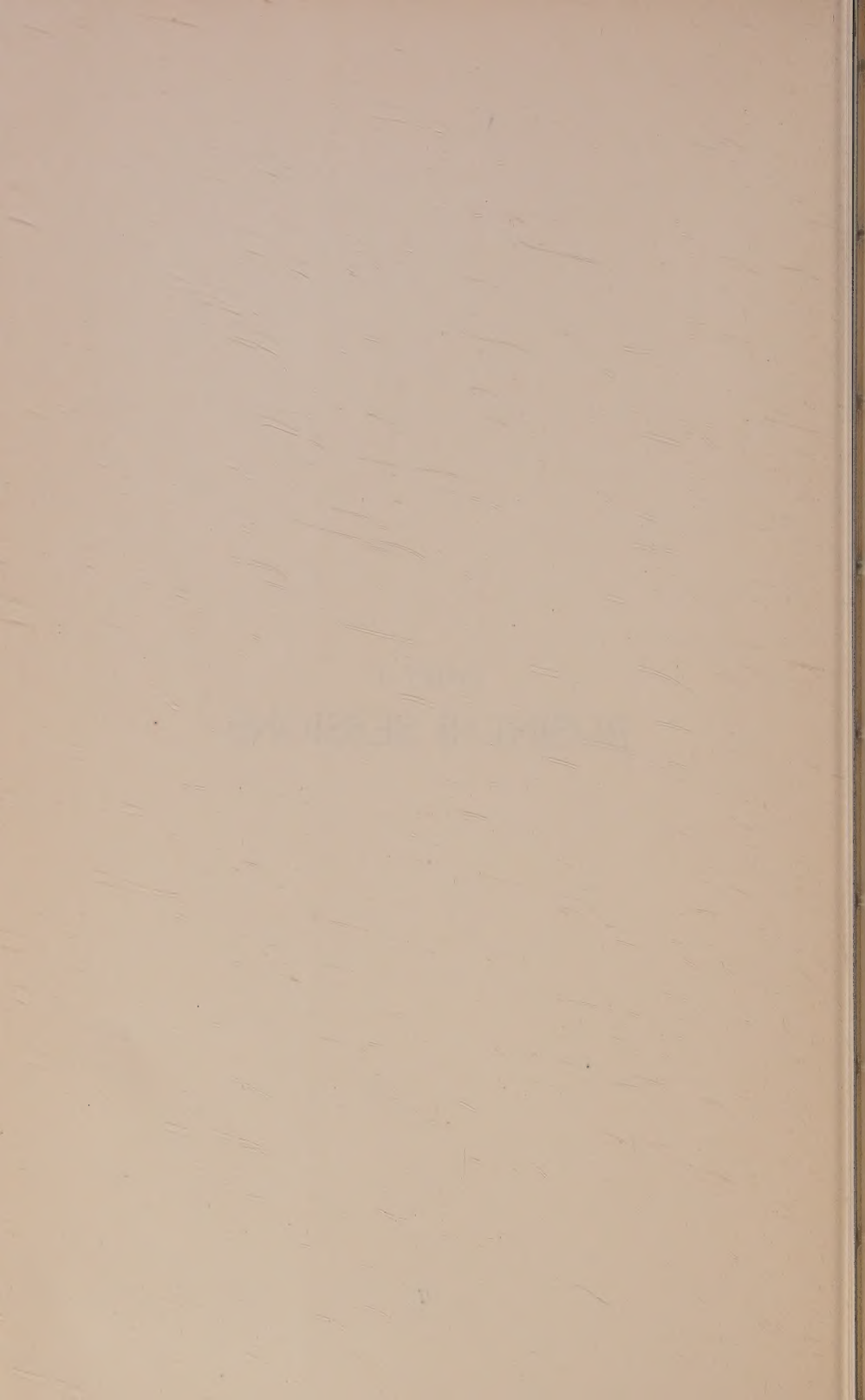
What Kind of Education do Fishermen Need. <i>Prof. E. E. Prince</i>	25
Fisheries Investigations in Massachusetts. <i>Dr. David L. Belding, Arthur Merrill and James Kitson</i>	29
Notes on the Control of Gyrodactylus on Trout. <i>Dr. Geo. C. Embury</i>	48
Transmission of Octomitus Salmonis in the Egg of Trout. <i>Dr. Emmeline Moore</i>	54
The Intestinal Protozoa of Trout. <i>Dr. H. S. Davis</i>	57
The Potential Importance of Artesian Wells. <i>Dr. James Alexander Henshall</i>	68
Conservation of Water Supply as Affecting Fish Life. <i>Hon. Honore Mercier</i>	72
Some Experiments on the Addition of Vitamins to Trout Foods. <i>Dr. H. S. Davis and M. C. Jones</i>	77
Habits and Propagation of Small Mouth Black Bass. <i>Henry W. Beeman</i>	92
Some Fish Cultural Practices in the New Jersey State Hatchery. <i>Charles O. Hayford</i>	108
Consumption, Not Production—Industry's Chief Problem. <i>J. A. Paulhus</i>	138
Development of Fish Culture in Canada. <i>J. A. Rodd</i>	148
Barren Lakes or Natural Nurseries for Fry. <i>J. A. Rodd</i>	161
The Sanitary Water Board of Pennsylvania. <i>Nathan R. Buller</i>	163
A Confirmation of Borodin's Scale Method of Age Determination of Connecticut River Shad. <i>R. L. Barney</i>	168
Age of Shad (<i>Alosa Sapidissima</i> Wilson) as determined by the Scales. <i>Prof. N. Borodin</i>	178
A Comparative Study of Natural and Artificial Foods of Brook Trout. <i>Dr. George C. Embury and Myron Gordon</i>	185

APPENDIX

Certificate of Incorporation	203
Constitution	204
List of Members	207



PART I
BUSINESS SESSIONS



PROCEEDINGS
of the
American Fisheries Society
FIFTY-FOURTH ANNUAL MEETING
at
QUEBEC, CANADA

September 10, 11, 12, 1924

The Fifty-fourth Annual Meeting of the American Fisheries Society convened at the Parliament Buildings, Quebec, on Wednesday, September 10th, at 10.30 o'clock a. m., President George C. Embody, of Ithaca, N. Y., in the Chair.

First Session, Wednesday Morning, September 10.

REGISTERED ATTENDANCE

EMMELINE MOORE, Investigator, Conservation Commission, Albany, N. Y.
EEN W. COBB, Brule (Douglas County) Wis.
EDWARD E. PRINCE, Commissioner of Fisheries, Ottawa, Canada
JAMES A. LAIRD, Southside Sportsmens Club, Oakdale, N. Y.
E. LEE LE COMPTE, 514 Munsey Bldg., Baltimore, Md.
HAROLD S. KOLMER, 514 Munsey Bldg., Baltimore, Md.
FREDERICK C. WALCOTT, Norfolk, Conn.
J. A. RODD, Ottawa, Canada
J. A. BELLISLE, Quebec, Canada
CHAS. O. HAYFORD, Hackettstown, N. J.
JNO. P. WOODS, First & Wright Sts., St. Louis, Mo.
GEO. C. EMBODY, Triphammer Road, Ithaca, N. Y.
GUY AMSLER, Game and Fish Com., Little Rock, Ark.
E. C. YOUNG, House of Commons, Ottawa, Canada
J. F. GOULD, Game and Fish Comr., St. Paul, Minn.
THADEUS SURBER, Supt. Fish Propagation, St. Paul, Minn.
S. A. SELVOG, Supt. State Fisheries, St. Paul, Minn.
LEE MILES, Little Rock, Ark.
JOHN W. TITCOMB, Board of Fisheries & Game, Hartford, Conn.
E. T. D. CHAMBERS, Quebec, Canada
J. B. DOZE, Fish and Game Warden, Pratt, Kansas
ARTHUR MERRILL, Wilkinsonville, Mass.
E. D. MERRILL, Wilkinsonville, Mass.
HERMAN O. HESEN, JR., Fairport, Iowa
KARL C. KULLE, Suffield, Conn.
J. P. SNYDER, Cape Vincent, N. Y.
JAMES A. KITSON, Boston, Mass.
WM. C. ADAMS, Boston, Mass.
DAVID L. BELDING, Boston, Mass.
WM. K. MOLLAN, Bridgeport, Conn.
GEORGE W. FIELD, Mass. Fish & Game Asso., Boston, Mass.
G. C. LEACH, Bureau of Fisheries, Washington, D. C.

A. H. DINSMORE, Bureau of Fisheries, St. Johnsbury, Vt.
 H. S. DAVIS, Bureau of Fisheries, Washington, D. C.
 HENRY W. BEEMAN, New Preston, Conn.

SWEPSON EARLE, Conservation Commissioner, Baltimore, Md.

H. H. JOHNSON, Conservation Commission, Baltimore, Md.

J. A. PAULHUS, Montreal, Canada

JAMES H. CONLON, Montreal, Canada

G. E. JENNINGS, Fishing Gazette, 465 Central Park West, New York, N. Y.

A. P. KNIGHT, Kingston, Ont.

DR. JAN METZELAAR, 539 East University Ave., Ann Arbor, Mich.

HONORE MERCIER, Minister of Land & Forests, Quebec, Canada

MYRON GORDON, Cornell University, Ithaca, N. Y.

NEW MEMBERS ELECTED

JAMES F. GOULD, State Game and Fish Commissioner, St. Paul, Minn.

S. A. SELVOG, Game and Fish Department, St. Paul, Minn.

THADDEUS SURBER, State Game and Fish Department, St. Paul, Minn.

J. A. PINKERTON, State Hatchery, Glenwood, Minn.

OLIVER MIX, State Hatchery, St. Paul, Minn.

HAROLD JENSEN, State Hatchery, St. Peter, Minn.

R. G. GALE, State Hatchery, French River.

JOHN HUDERLE, State Hatchery, Detroit, Mich.

A. C. KLANCKE, Game and Fish Department, St. Paul, Minn.

ANSON W. HARD, Sayville, L. I., N. Y.

HAROLD S. BOWER, Department of Conservation, Lansing, Mich.

WM. E. DICKINSON, Public Museum, Milwaukee, Wis.

J. S. JACOBS, Springfield, Vermont

JAMES A. KITSON, 506 State House, Boston, Mass.

PHILIP H. MITCHELL, Brown University, Providence, R. I.

RAYMOND L. BARNEY, Middlebury College, Vermont

A. P. KNIGHT, Chairman of the Biological Board of Canada, Kingston, Ontario

RALPH BITYER, Montague, Mass.

LOUIS HORST, Sunderland, Mass.

R. H. CORSON, Assistant Superintendent of Telegraph, 25 Tonnele Ave., Jersey City.

SWEPSON EARLE, Conservation Commission, Baltimore, Md.

HON. J. E. PERRAULT, Minister of Colonization, Mines and Fisheries, Quebec

L. A. RICHARD, Deputy Minister of Colonization, Mines and Fisheries, Quebec

REPORT OF THE EXECUTIVE SECRETARY

The Transactions of the Society for 1923 were mailed to all who had paid their dues. Most organizations of this kind do not send their publications to members unless the dues are paid in advance, and this policy was adopted by your secretary. Heretofore the Annual Reports have been mailed to people who were in arrears for membership fees and dues. Many who have never paid them have received five or ten dollars worth of publications.

At the last annual meeting I took it upon myself, in view of the financial condition of the society, to recommend that the officers serve without salary. We had been paying the secretary \$300 a year for quite a few years and then paying his assistant for doing some of the

work. Not being present at the session when the election of officers took place I had the secretarial honor thrust upon me, and I was sport enough to take it for the year, to serve without honorarium. The appointment of an editorial staff relieved the secretary of a great deal of work. I was very fortunate in having a secretary on whom I thrust most of the work. Her work consisted, first, of getting the transactions published, reading the proof and correcting it, then getting a corrected proof and reading that. Then there were the personal appeals to State Game and Fish Commissions to identify themselves with the Society. Many commissioners stated that they could not pay out of their funds any money for the purpose of joining the Society, but in some instances they could buy the Transactions at \$3 each for distribution to their employees and others interested in the work.

I have taken an inventory of all our publications and find that the Society has not one complete set of its own publications. There are many years where we are short; for some years we have none at all, and for other years we have a great number of copies. I tried to obtain for the Society, either through gift or sale, the numbers that we were short. I had an opportunity to sell a complete library of the Transactions, which would have brought us in about \$200 had it been possible to furnish a complete set. The members as a whole do not appear to appreciate the value of this publication. Perhaps they will when they see that they now cost \$3 a volume. The Transactions for 1923 are sold at \$3; 1906 to 1922 at \$2, and 1876 to 1906 at \$3.50. It would be well worth while for you to look over your attics and see if you cannot rake up some of these old volumes. We have a call for them if you do not want to keep them.

The Transactions which, because it was thought more economical, were published quarterly during a number of years, proved to be our most expensive investment. For instance, for 1915 we have 110 March Quarterlies, for June, 132, and for September, 12. Now, nobody wants an odd copy of that Quarterly, and we have only 12 complete copies of the Transactions for that year. For 1916 we have 207 of one Quarterly and 55 of another; for 1917, 213 of one Quarterly and 82 of another; for 1918, 233 of one Quarterly and only 76 of another.

I am going to be perfectly frank with you in regard to the secretary's work. I am not going to allow you to thrust that honor on me again. Perhaps you won't want to after I have been disagreeable enough to tell you the whole story. Let me compare the expenses of the secretarial and treasurer's work this last year with those of the previous years. We have paid for the printing and distribution of the publication, \$575. The cost the previous year was \$1,078.84, so we saved \$503.29 on that item alone. It was published at the Connecticut State Reformatory. It is not quite as neat a publication as that of former years, but it is pretty good—it took a little more care in the matter of proof reading.

We omitted the list of members this year. I think we ought to publish it occasionally, but we are trying to economize. By cutting that out and by eliminating extraneous matter such as the stories you tell here, the jokes and matter that is a repetition, we saved fifty-three pages. Last year's report, which cost \$1,078, consisted of 257 pages, while this year's consisted of 214.

For the printing, the secretarial work, circulars, and that sort of thing, we expended \$50.55 against \$121.65 the preceding year, making a saving of \$62.34. In the clerical assistance and secretarial work, cutting out the salary of secretary, we saved \$259.71. The total saving was about \$1,020.94, as near as I can figure it, over that of the previous year. The treasurer's report will show that all of the bills that were hangovers from 1922 have been paid; that all the bills for 1923 have been paid and that there is a slight balance in the treasury.

We have quite a list of delinquent members. You would be astonished at the people who drop out. Some of them pay nothing for two or three or four years, the publications having been sent to them during that time; they drop out for a year and then join again, so they get ahead of the game in that way—it does not seem to be quite the square thing.

For the benefit of my successor in office, I may add that it has not been the custom, apparently, to turn over to the secretary the correspondence of the previous year. I shall be glad to turn over a complete file of it. It seems to me that the Transactions we have on hand, which constitute quite a body of material, ought not to move about from year to year, and that it might be well to have a librarian who is willing to care for and dispose of them at stated prices. The publications are valuable books; libraries are commencing to appreciate their value and are trying to complete their sets. We sold books in countries as far distant as New Zealand this last year; all over the world we have had demands for them.

JOHN W. TITCOMB,
Executive Secretary.

REPORT OF THE TREASURER

Milwaukee, Wis.,
September 2, 1924

TO THE AMERICAN FISHERIES SOCIETY:

Herewith is submitted the annual report of the Treasurer covering the period from the last annual meeting at St. Louis, Missouri, in September 1923, to August 30, 1924, inclusive.

In reviewing the finances of the American Fisheries Society the writer suggests that the fees for the Life Members and Patrons be raised to \$75 and \$100 respectively. At the present time the amount received from Life Members is not only wholly inadequate from a financial standpoint but also apparently unjust to the large number of active

sustaining members. At the present date the sum of \$25.00 only covers a little over eight years of regular active dues and after such has expired the member is carried for the remainder of his life on the rolls of the Society as a dead-loss financially. The writer believes that a payment equivalent to twenty-five year's active dues should be demanded. The majority of other scientific societies charge the amount above mentioned for similar membership.

Attention is called to the necessity of members paying their dues promptly and regularly. The Society is and has been carrying too large a percentage of members that are lax in this regard.

Without further comments the writer begs to present for your consideration the following items:

GENERAL FUND

Receipts

Balance on hand at meeting of 1923		\$	98.68
Annual Dues			
Individuals and Libraries			
For the year 1920	\$	4.00	
For the year 1921		42.00	
For the year 1922		114.00	
For the year 1923		1,121.62	
For the year 1924		36.75	
For the year 1925		7.01	
For the year 1926		3.00	
Clubs and Dealers			
For the year 1922		10.00	
For the year 1923		135.00	
For the year 1924		10.00	
State Memberships			
For the year 1923		120.00	
Life Memberships		200.00	
Sale of Publications		76.34	
Donations		87.06	
Refunds		10.00	
			1,976.78
Total Receipts		\$	2,075.46

Disbursements

On account of year 1922 (Prior Administration),			
Printing Transactions for 1922, vol.			
52, balance of bill due	\$478.84		
Salary of Secretary Bower	300.00		
Clerical assistance to Secretary	50.00		
Miscellaneous expense of Secretary	27.08	\$855.92	

American Fisheries Society

Transferring Secretary's Office	48.21	
Transferring Treasurer's Office	1.26	49.47
On account of year 1923 (Present Adminstra- tion), 1923 Meeting at St. Louis, Mo.,		
Reporting proceedings of meeting	250.00	
Stenographic assistance	1.00	
Printing programs and badges	21.50	272.50
Transactions, 1923, vol. 53,		
Printing, 750 copies with plates	489.05	
Mailing envelopes and postage for	86.50	575.55
Expenses of Secretary's Office,		
Printing of Stationery, Applications,		
Circular letters, etc.	50.55	
Postage and suplies	8.76	
Clerical Assistance	100.00	
Purchase of publications	12.00	171.31
Expenses of Treasurer's Office,		
Printing of Stationery and Bills	17.50	
Multigraphing Service	8.95	
Postage and telegram	31.47	
Supplies (rubber stamps)	1.65	
Clerical Assistance	50.00	109.57
Bank refunds and adjustment	22.00	
		2,056.32
Balance on hand	\$	19.14

PERMANENT FUND

Receipts

Balance on hand at meeting of 1923	\$	1,644.97
Interest to date of deposit, Oct. 23, 1923	\$	66.42
Interest to date, Aug. 30, 1924		29.99
Total Receipts	\$	1,741.38

Disbursements

		0.00
Balance on hand	\$	1,741.38

MEMORANDUM

All outstanding obligations of the Society, known to the writer, on account of past and present administrations having been paid, the total indebtedness of the Society appears to consist only of the item of \$1,369.74 plus interest reported by former treasurer, A. L. Millett in his report of Sept. 12, 1923, as the balance due the Permanent Fund. It is believed, however, by the writer that this sum can be restored to the Permanent Fund in two or three years if the revenue and expenses of the future does not materially change from that just reported above.

Respectfully submitted,

T. E. B. POPE,
Treasurer.

REPORTS OF DIVISIONS

Dr. Emmeline Moore presented the report of the Vice-President, Division of Aquatic Biology and Physics.

Mr. President: This is the first time a formal report of this division has been presented to the Society. When elected to the office last year I was somewhat at a loss to know how the Division should function. On looking up the records I found that this Vice-Presidency, and the other four, were created in 1910 by constitutional amendment, with duties suggested in the titles. "For instance," to quote from the author of the amendment, "The vice-president of fish culture will push his line, the vice-president of biology will push his line and so on."

My distinguished predecessors during the past 14 years have vigorously and effectively "pushed their line." To wit, the achievements of past vice-presidents Linton and Ward, in the field of parasitology. These tireless investigators have made known the cause and the mechanism of many fish diseases so that neither time nor money need be wasted on them in doctoring symptoms. They have enabled the fish culturist to do more than adopt the proper curative measures—they have enabled him "to change his strategy and assume the defensive in the battle against diseases."

I cite also the monumental work of past vice-president Birge and his keen ally, Mr. Juday, who have shown that aqui-culture is as susceptible of scientific treatment as agriculture can be. And if all their dreams come true the harvest of the fisherman will surely be less precarious—he will actually reap what he has sown. Already in the matter of food relations they are telling us how markedly a plump cyclops differs in essential constitution from an ordinary midge larva which is almost destitute of fat.

Mr. President, I am not submitting a report of my work, for as chairman of this Division I have done nothing. I find myself in the predicament of the theological student who was weak in his examination.

When asked to distinguish between the major and the minor prophets he answered, "Far be it from me to distinguish between the major and minor prophets. Here follows a list of the kings."

I have a notable list to present of others who, either as individuals or departments are "pushing their line" in various directions within the scope of this division.

The contributions to Canadian biology are well known to us. The studies by Dr. Clemens on the physics and biology of L. Ripigone have given us much new information about the whitefish. Studies on the biology of the shad by Mr. Leim are awaited with great interest. The work of Dr. Huntsman on the causes of migrations of the sea fishes help to answer an age old question of why great schools of fish move about. He says: The "influences that control the movement of the plankton i.e. temperature, light, and salt, must also control to a large extent the movements of fish that feed upon them."

The researches of Dr. Herbert S. Davis, pathologist for the U. S. Bureau, offer something more substantial than hope to the fish culturist. From his vantage point in the bureau he is attacking the more immediate and pressing problems in fish pathology and bringing them forward into the field of experiment.

Forthcoming contributions from the Connecticut Department of Fish and Game deal with the biology of the shad and related subjects in shad propagation, migration, etc. The Connecticut Commission has so to speak blown the dust off that splendid work of Ryder and Rice on the biology of shad, reposing on the shelves these 40 odd years, and having brought it into the light of modern day, they are building upon it in important constructive ways to forestall the depleting supply.

Dr. A. S. Pearse, of Wisconsin, is measuring with scientific precision the tastes and appetites of our common food fishes.

Dr. Embury, our honored President, is attacking the problem of breeding for disease resistance in trout.

The Danish Biological Station and the English Ministry of Agriculture and Fisheries, undaunted by the profundity of the problem are stopping at nothing less than an "Evaluation of the Sea."

These are some of the live subjects occupying scientists within the field of aquatic biology and physics. They bear testimony that the leaven of scientific inquiry is working so silently and strongly toward the elucidation of our problems that I venture to say a lapse of another 14 years without a report need not be "viewed with alarm."

Respectfully submitted,

EMMELINE MOORE,

*Vice-President, Division of
Aquatic Biology and Physics.*

September 10, 1924.

Report of Committee to attend the President's Conference on Outdoor Recreation by Mr. Walcott.

Mr. President: In all the history of the United States there had not been until this year one official word from the President, so far as we could find out, on the subject of Conservation. On May 16th of this year a Conference was called of representatives from every out-of-door section of the country, including everything from Child Welfare to the Conservation of the Forests, Fish and Game. This was the first message, so to speak, from the President of the United States to all the people of the United States that out-of-door recreation was of prime importance. The Conference was an exceedingly comprehensive one. It was attended by five or six hundred delegates, and President Coolidge in his opening address, which did not take more than twelve or fifteen minutes, made a clarion call that rang all over the world—it was a wonderful thing. It would be an ideal paper to read here this morning; it would stimulate us and thrill us as to the possibilities of an heritage which has almost been forgotten and which is almost entirely neglected by us. In Canada you do not need that message so much, but we need it very much indeed, and we got it from President Coolidge. The Assistant Secretary of the Navy, Theodore Roosevelt, rose to his duties as Chairman of the Executive Committee; his father could scarcely have done better as presiding officer over that Conference, which lasted for three days. The final result was a permanent organization with a highly paid secretary—when he can be found. The secretary pro tem is Vernon Kellogg, a California biologist, now Secretary of the National Research Council, who will carry out the duties of the office until the right man can be found to take the position permanently. It is the duty of that secretary to keep in touch with Washington all organizations of this kind throughout the country. The work of the first Executive Committee appointed by the President, consisting of the members of his Cabinet, concluded with the Conference, and the permanent secretary takes the place of the Chairman of the Executive Committee. A permanent Executive Committee, outside of the Government, has been set up, of which Mr. Chauncy Hamlin of Buffalo is Chairman. Contact with the executive arm of the Government will thus be established. This is the first time anything of that sort has been done, and it promises to yield very important results. Too much emphasis cannot be laid upon the importance of our establishing contact with that permanent organization in Washington, so that we may not only keep the Federal Government advised of our doings but also get that co-operation from the Federal Government which they are pledged to give. This step marks a new era in conservation in the United States.

APPOINTMENT OF COMMITTEES

Time and Place: Messrs. Hayford, Miles, Cobb and Rodd.

Nominating Committee: Mr. Woods, Mr. Buller, Dr. Belding, Dr. Moore and Mr. Walcott.

Auditing Committee: Mr. Kulle, Mr. Lecompte, and Judge Miles.

Resolutions Committee: Mr. Adams, Dr. Prince, Dr. Davis.

The Committee on Time and Place reported recommending that the Society meet next year at Denver, Colo., during the week commencing the third Monday in August.

The report was adopted unanimously.

REPORT OF THE COMMITTEE ON NOMINATIONS

The Committee reported the nomination of the following officers.

<i>President</i>	E. W. COBB, Wisconsin
<i>Vice-President</i>	CHARLES O. HAYFORD, New Jersey
<i>Executive Secretary</i>	CARLOS AVERY, Minnesota
<i>Recording Secretary</i>	FLOYD S. YOUNG, Illinois
<i>Treasurer</i>	T. E. B. POPE, Wisconsin

Vive-Presidents of Divisions:

<i>Fish Culture</i>	DR. EMMELINE MOORE, New York
<i>Commercial Fisheries</i>	J. A. PAULHUS, Canada
<i>Aquatic Biology and Physics</i>	DR. H. S. DAVIS, Washington, D. C.
<i>Angling</i>	LOUIS DENNING, St. Louis
<i>Protection and Legislation</i>	W. H. DILG, Illinois

Executive Committee:

J. A. RODD	Ottawa, Canada
LEE MILES	Arkansas
HONORE MERCIER	Quebec, Canada
SWEPPSON EARLE	Maryland
W. E. ALBERT	Iowa
M. D. HART	Virginia
J. B. DOZE	Kansas

The report of the Committee was unanimously approved.

RESOLUTIONS ADOPTED

Resolved, That the thanks and appreciation of the American Fisheries Society be extended to His Honor the Lieutenant Governor of the Province of Quebec, His Worship the Mayor of Quebec, the Hon. Honore Mercier, Minister of Lands and Forests; the Department of Marine and Fisheries; the Hon. J. E. Perrault, Minister of Colonization, Mines and Fisheries,

and the Department of Provincial Fisheries, for the splendid hospitality so fully extended to the members of the Society.

Resolved, That the thanks of the American Fisheries Society be extended to the Press of the City of Quebec and the Dominion of Canada for their cooperation and the excellent publicity given to the proceedings of our meeting.

Resolved, That the thanks and appreciation of the Society be extended to President Embury, whose able administration of the affairs of the Society during the year and dignified leadership during the meeting have been of great value.

Resolved, That the cordial thanks of the Society be extended to Mr. John W. Titcomb, and Mr. T. E. B. Pope, for the able and efficient manner in which they have discharged the duties of their respective offices of secretary and treasurer of the Society.

Resolved, That the American Fisheries Society express its appreciation of the interesting and valuable paper submitted by Dr. Henshall, long a member of the Society and now eighty-nine years of age. It is the hope and wish of this Society that he may continue to enjoy good health and annually contribute many more papers characteristic of his great store of information. Further, that a copy of this resolution be communicated to him.

Resolved, That the President of the American Fisheries Society address a communication to the President of the Izaak Walton League of America expressing our appreciation of the stand taken by the League in its efforts to preserve and increase the fish life in the public waters of the United States; further, of the interest manifested by the League in the Act known as the "Upper Mississippi River Wild Life Game and Fish Refuge Bill," and its instrumentality in securing the passage of this Bill by the last Congress whereby \$3,000,000 is to be set aside by Congress for the purchase of certain low lands along the Upper Mississippi River for the protection of game and fishes.

Resolved, That the Society express its commendation and approval in a letter to the Honorable Secretary of Commerce and the Commissioner of Fisheries of the United States for the stand they have taken in securing the passage of legislation for the protection of the west coast salmon and halibut fisheries, that these valuable species may be protected from exploitation and preserved for posterity.

WHEREAS, the Congress of the United States has authorized the President and the Secretary of State to call an international conference to devise a program for checking the unnecessary pollution of the extra-territorial waters; and,

WHEREAS, the Federal Oil Pollution Act of 1924 is now in force relative to navigable coastal waters, and state laws are being made effective, thus covering each aspect excepting only the international; and

WHEREAS it is our well considered opinion that the discharge of oil in extra-territorial waters is of great actual damage; moreover, that the discharge resulting from each day's delay causes great and persisting economic loss to the fishing industry, and to marine organisms upon which our fishing industry directly depends, more than can be compensated by any delay in expectation of devising a specially serviceable reclaiming apparatus;

Therefore, be it resolved that the Honorable the Secretaries of State and of Commerce be urged to use their good offices to have the conference called at an early date in order that the adoption of efficient measures for the prevention of unnecessary pollution in extra-territorial waters may not be further delayed.

Be it further resolved that the thanks and appreciation of the Society be extended to the Honorable the Secretary of Commerce for the stand he has taken for the enactment of Federal laws for the prevention of oil pollution in the territorial waters of the United States.

WHEREAS, several years ago, following the joint adoption by the Dominion of Canada and the United States of the reports of the Joint Boundary Commission which resulted in the establishment of the international boundary and the designation of international waters, the Treaty suggested and recommended to the countries the formation of an International Joint Fisheries Commission to govern through joint rules and regulations commercial fishing operations in such international waters, and,

WHEREAS such a Commission was duly appointed and discharged its duties and submitted its reports to the Dominion of Canada and to the United States, and

WHEREAS the Dominion of Canada long ago accepted and put into effect through the enactment of proper legislation the rules and regulations recommended, such being operative today, and,

WHEREAS, the United States Congress has not yet ratified such rules and regulations and, as a result, the several states along the international boundary have enacted commercial fishing laws which differ materially and do not conform to the laws of the Dominion of Canada;

Therefore be it resolved, that the United States Congress be requested to carry out the obligation of the United States Government at this time through the reconsideration of the International Commercial Fishing Treaty and accompanying rules and regulations, and the enactment of legislation to carry out the provisions thereof.

Be it further resolved, that copies of this resolution be forwarded by the secretary to the President of the United States, the Secretary of

State, the President of the Senate, the Speaker of the House of Representatives, and the members of the Senate and House of Representatives who are on the committees which will consider this matter.

Resolved, that the members of the American Fisheries Society present in the City of Quebec feel bound to accord their appreciation of the indefatigable efforts of Mr. E. T. D. Chambers, Special Officer of the Department of Lands and Forests and the Fisheries Department, in contributing to the success of this meeting and to the comfort and pleasure of the members.

In Memoriam

DR. CHARLES MINOR BLACKFORD

SEYMOUR BOWER

JOHN S. CASSELL

OSWILL CHAPMAN

HENRY F. DE PUY

CHARLES S. MARDEN

ALFRED MOORE

GEORGE W. PELL

W. P. THOMPSON

PART II
PAPERS AND DISCUSSIONS

WHAT KIND OF EDUCATION DO FISHERMEN NEED

BY PROFESSOR E. E. PRINCE,

Ottawa.

When discussing the Canadian system of administering and developing the fisheries of Canada with a Hindu official of high rank, Sir Krishna Gupta, some years ago I found that in India the fishermen all belong to a caste—a rather lowly caste which other castes look down upon. It is impossible to become a fisherman if you belong to a higher caste. Now though many people may look down upon the class of fishermen who live by fishing, they are not unintelligent or unworthy of our esteem and appreciation. They offer a fine field for education and training. Some authorities, in my opinion, do not really appreciate the real educational needs of the fishermen, especially Atlantic coast fishermen.

I appeared before the Canadian Technical Education Commission and the questions put to me indicated that in the opinion of the commissioners fishermen did not know how to catch fish. Can you not suggest a system of education and training that will make them more successful and largely increase their catches? That was the kind of questions put to me. My reply was that no one can teach a fisherman how to catch fish. In that they were most accomplished. The catches were in many fisheries really too large—the men too well know how to make big catches. Overfishing and exhaustion were two great dangers.

Education and training are, to my mind, as desirable in the case of fishermen as in the case of farmers. Fisheries can benefit from science as surely as agriculture and mining. Fishermen cannot spare time to devote to unnecessary training. Instruction that is merely scientific or merely interesting information should be excluded. It is not urgent and there is not time for it.

As there are many papers to follow I shall be as concise as possible and suggest rather than expound the branches of knowledge which the fishermen really need. There are 12 branches: (1) A brief general survey of the fisheries of the coast and offshore waters adjacent to the abodes of the fishermen concerned. The past history and development and the present extent and possibilities of the resources.

(2) Life history of fishes, habits, spawning, food and migrations and some hints on classification and structure.

(3) Methods used in fishing—new methods which might be successful.

(4) Navigation. Use of charts, compass and sounding apparatus. Taking of salinity, density, temperature and similar observations at sea. Tides, currents and circulation of water. Sufficient engineering instruction to cover the operation of oil motor power and management and repair of engines. Knowledge of twine and repair of nets too is valuable; not net making because they are now made by machines.

(5) The hauling, icing, and landing of catches. Dangers and risks to be avoided, especially exposure to the hot sun, and damage due to gaffing, squeezing, trampling, and using fish roughly. Guarding in every way against spoiling the keeping and marketable qualities of fish; gutting, bleeding and filleting.

(6) Bacteriology of fish and fish food products, with popular explanation of recent scientific researches. Fermentation, putrefaction, autolysis, sterilization and the related study of sanitation in the matter of fish sheds, storage and freezing establishments, curing houses and canneries.

(7) Preservation methods, the principles of icing, chilling and freezing fish, also salting, curing, smoking and canning fish products, with the avoidance of faulty and dangerous processes.

(8) Fish propagation. Best methods of breeding and operating hatcheries, preventing destruction of young fish. This would include a study of fish enemies and inimical conditions. Causes of injury to fishing grounds: gurry, ashes, oil, pollution, etc. Lobster, oyster, clam, mussel and cockle culture under natural or controlled artificial conditions.

(9) Principles of fishery legislation and administration by governments. Enforcement of conservation laws, reasons for close seasons, size or weight limits, etc., and the desirability of creating a healthy public opinion amongst fishermen and the nation.

(10) Fish waste and utilization of valuable products—such as roe, oil, fish skins for glue and leather. Methods of saving, collecting, transporting, preparing and marketing fish fertilizer and other products.

(11) Medical treatment and first aid: the simplest and most useful information, including saving and restoring the drowning, attending to the injured, care of wounds, and, above all, proficiency in swimming. Fishermen as a class, though spending their lives on the water, rarely know how to swim. They have the crudest ideas about saving drowning comrades; as an example, I once saw a fisherman who

fell overboard gaffed like a fish with a boat hook—a horrible method of rescue. The man was injured for life in the back where the boat-hook pierced him.

(12) Fish as food. Qualities of different fish as ascertained by dietetic science. For instance, the wolf fish (*Anarhichas lupus*), the angler fish (*Lophius piscatorius*), the rock eel (mother of eels) (*Zoarces viviparus*) are all delicious, firm, white-meated and of excellent flavor. The wolf fish is said to be the best fish that swims.

Fishermen do not understand physics, mathematics, chemistry or profound scientific principles. Even the idea of a gas (expansion or diffusion) is difficult to picture to them. Is it worth while to burden their untrained minds? It is sufficient to give them plain, practical knowledge which their plain matter of fact minds can grasp, and which they can master in the limited time at their disposal.

What would be the effect of a brief and not too technical and taxing course of fishing instruction. It would arouse a new interest in the minds of fishermen. They would see more in their calling than they usually do now, and they would realize what a wonderful and valuable heirloom they are exploiting. A healthy sentiment would be aroused and they would understand and be prepared to welcome and assist in the administrative and legislative efforts of governments to conserve and preserve the fisheries, some of which seem to be within measurable distance of extinction. Government officers need the support of the fishermen and of the public. Injurious and foolish methods such as the use of explosives, etc., would be abandoned. Destructive fishing, such as the killing of young, immature fish, would be stopped if fishermen were taught to think and to appreciate what I might call the rights of the fishes themselves.

Discussion

MR. TITCOMB: I would like to bring out a point which I have had occasion to bring out with the fishermen. In a great many states legislation relating to the commercial fisheries does not emanate at all from the fishermen, and very often they are not consulted as to their views. Dr. Prince spoke about educating the fishermen as to the reasons for the laws. The point I want to bring out is this: while the fishermen often will not agree to any legislative protection, it is a mighty good policy to consult them, to get them together and let them talk it over, if they will; let them discuss the proposed new legislation. Let them think they have something to say about it. It is my personal knowledge that very radical legislation on the commercial fisheries has been enacted in some legislatures without consulting a single commercial fisherman, and I believe that is all wrong. Get

them to discuss these questions themselves. Find out as soon as possible what the majority of them will agree upon. Get a few of the best informed among them to co-operate in the proposed legislation.

PRESIDENT EMBODY: May I ask Dr. Prince whether they are giving any courses in fisheries work at the University of Liverpool? I think they were contemplating work of that kind a few years ago.

PROFESSOR PRINCE: That question came up at the meeting of the British Association for the Advancement of Science, at which some representatives from Liverpool University were present. The late Sir William Herdman was the leading man in that field. I had an opportunity to speak to Dr. Dakin and others on the question, and I understand that they have carried on courses of instruction on the Isle of Man among the Manx fishermen. They found the fishermen very enthusiastic about this educational work. In North Wales also they have a station where they get the fishermen together. I do not think they instruct the fishermen in the university itself, but rather on the seacoast. The work was done at two biological stations. The University of Liverpool has, then, carried on a number of courses, especially dealing with the eggs and the young of fishes. I am rather in doubt myself about the benefit of showing the fishermen things under the microscope, on account of their inability to grasp what the conditions of microscopic optics are. When I was in university several years ago and had a large number of elementary medical students in their first year, it was very difficult to get them to understand what a section was. I do not think that microscopic work among fishermen would really be very successful, but I may be wrong in that.

PRESIDENT EMBODY: There is no such organization however, as a distinct college of fisheries there?

PROFESSOR PRINCE: No.

FISHERIES INVESTIGATIONS IN MASSACHUSETTS

BY DR. DAVID L. BELDING, ARTHUR MERRILL AND JAMES KITSON

DR. DAVID L. BELDING (Boston): Mr. President: In order to present to the Society certain phases of the work in Massachusetts my co-workers have decided that the subject can be dealt with in a much shorter time if the topics are outlined by one person. As each topic is outlined I suggest that it be thrown open to discussion and that any remarks be confined very strictly to that particular topic; then having completed that topic we will go on to others.

We shall attempt to cover two general subjects: first, the effect of water pollution upon fish—certain phases; and second, the general subject of fish distribution. We shall endeavor to present the topics in a specific manner; that is, we will use concrete illustrations to bring out general points. We will also take up certain definite phases of the work and avoid as far as possible the general topics which do not have a concrete bearing upon the matter in hand.

I may add that what we shall present for your consideration is what we have met in our experience in practical work.

The first topic is that of Available Factors in Experimental Work in the Direct Effect of Water Pollution Upon Fish. By that I mean we are dealing with the actual effect of polluting substances in the water upon the fish, and we do not consider the perhaps greater but more indefinite and indirect effects of pollution upon fish environment, food, and so on. All our remarks will be confined to the actual direct effect of pollution upon fish; we shall not go into the various incidental, though important influences upon fish life brought about by the presence of sewage or trade wastes in our fish waters.

Certain factors we found affected the results of various tests made with chemical or other substances upon fish. So available were results that it seemed to us almost impossible to establish exact figures as to the effect of certain chemical substances upon fish, and you can only appraise the results of the work of various investigators upon this subject in general terms. You cannot say that a certain dilution of sulphuric acid, of carbolic acid or copper sulphate would kill fish because the available conditions under which the tests were made were such as to permit a very wide range in the toxic or lethal dose of that substance upon fish. I have outlined here for you certain factors which cause this variation. The first I have grouped under the fish themselves; the second under the environment which the experimental work is conducted.

First, the individual variations of the fish. Anybody who has done any great amount of laboratory work knows that in

the laboratory animals, like human beings, show marked individual variations; that what might kill one individual might not have the same effect upon another. From individual variations, therefore, we can derive the fact that we must use suitable numbers of fish in our streams, and more particularly must we use suitable numbers of controls. If you happen to select a few weak fish and test the lethal dose of any chemical substance you get a much greater dilution of the substance than you would in the case of strong, normal fish.

The family. By that I mean that certain fish are more hardy than others. I do not think I need to demonstrate that, more than to say that the trout is very much more susceptible to hydrogen sulphide than the carp, carp requiring about seven times as much hydrogen sulphide as trout, and goldfish about twenty-eight times.

Species. Individuals of the same family show different variations. As an example we will take a pool in which there has come a certain amount of pollution of copper sulphate. In that pool were brook trout, rainbow trout, chinook salmon. The salmon were all killed quickly. A few brook trout were killed—the majority showed the effects of the toxic salt. None of the rainbow trout showed any marked effect. There is a marked difference in closely allied species.

Age, size, weight perhaps go together. Certain chemical substances that may perhaps kill adult fish will not kill, in the same dilution, smaller fish, and we get the reverse of that. For example, with sulphuric acid the smaller fish survive better than the larger, while the reverse is true with carbolic acid, a more irritating poison.

Domestic against wild stock. Here the results depend on the question of the activity of the fish and the containers in which they were held during experimental work. In certain cases we may get better results with the domestic stock which are accustomed to confinement, and in other cases we might get better results with the wild stock. The fact that at certain seasons and times of the year there is a difference in the vitality of fish—as in the breeding season, for instance—should also be considered.

In connection with environment there is the question of the nature of the water. Instances have been known where the same chemical in different water required an entirely different dilution to obtain the death of the fish. Fish brought from one environment to another for experimental purposes would be rendered more susceptible by the new environment of the water. For instance, take the alewife and put it in the trout hatchery, or take the common bull-

head; as a result of the changed environment these fish will probably perish or become very much less resistant. That actually did occur in a particular instance I have in mind.

Then, there is the question of the containers, and more particularly the ratio of the fish to the containers. If the container has not a sufficient surface area to permit absorption of oxygen, you have the oxygen factor to contend with. If you have large fish in a small container, more oxygen will be used up. You would also have other factors coming in, depending on the size of the fish and of the container. For instance, if you keep small goldfish in aquaria you have difficulty in using a container of the same size for work with trout.

Flow of water. Naturally if the investigator is reporting upon the toxicity of a certain chemical upon species of fish the ideal condition would be no flow of water. That is not possible in some places, and some have permitted a certain flow of water; and naturally the dilution of the chemical was only the initial dilution at the beginning of the experiment. Likewise, too severe a flow might wash the fish down against the screens. That is perfectly possible in the case of a weak fish affected by the chemical; if kept in that position it would probably perish earlier than one that had not been so placed.

The Amount of Oxygen. I have already mentioned that you need a certain level of oxygen in this work; that you have an oxygen factor to contend with, even if the particular substance with which you are working has no oxygen demand.

Temperature of Water. That is a very important factor. High temperatures induce a lessened resistance on the part of the fish—increased metabolism, and produce toxic results at a much lower dilution than in colder water. As an example of that, it takes about four times as much hydrogen sulphide in water of 35 to kill carp or bullfish as it does in water of about 60.

I should like to throw this phase of the subject open to discussion.

MR. TITCOMB: We all agree with you, doctor.

DR. BELDING: In connection with the next topic I desire to present what, so far as I know, is a new method which may be helpful in studying the effects of certain polluting substances. It comes under the head of Changes in the Respiration. I will not go into the details of the normal respiration of the fish, except to say that fish have to have oxygen and that they give off CO_2 as human beings do. The blood passes through the gills, there receiving oxygen, and

the same way as the blood passes to the lungs in human beings. The fish take water through the mouth and through the closing of the mouth it is forced out between the body and the gill cover. You have a mouth movement followed almost immediately by an extension of the gill cover and then a closing back. I call that the respiratory movement of the fish. You can observe and count the respirations of fish. Under normal conditions the rate varies a great deal, but you can get the rate the same as a physician can get the pulse of a human being or take the respiration. Now, there are certain physiological changes in the respiration; various species have different rates of respiration. With increased temperature you get a higher rate of respiration, due probably to increased metabolism of the fish, although in some cases to diminution of the oxygen in the water. You get it with exercise—activity on the part of the fish. You can get it in the change in the environment. If you take a carp and put it in a tub in which there is not enough water to cover the fish, the carp will live for a longer time that way than some other fish because they are able by the threshing action of the gills to get air the same time as water. You can carry on experiments in shallow water—in wash tubs, for instance—and observe the effects upon different species of fish. The minute you transfer the fish to a new environment you get an increased rate of respiration, possibly due to handling and to a variation in the environmental conditions, and it takes them a certain time to readjust themselves to the normal rate again. The size and age of the fish also make a difference in the respiratory rate.

I have included under this head a diminished oxygen content of water under normal conditions. You can diminish the oxygen content of water to a certain point and call that normal. Naturally there will be a condensation on the part of the fish with increased respiratory activity when there is diminution of the oxygen beyond a certain point; still, that may be within normal limits. As to the question of diseases, there is probably not so much change in the respiration with bacterial disease, as we think, because before we get to the final stage there is some acceleration and towards the last, just before the death of the fish, there is a slowing of the respiratory action coupled with various changes in rhythm, force and depth. Diminished oxygen is a cause of respiratory change. I will call your attention to the chart for a moment. The black line refers to trout and red line to carp. The solid line represents the respiratory activity with diminished oxygen. On the right I have given numbers corresponding to the rate per minute. On

the bottom is the time in minutes over periods running up to 90. If a trout confined in a closed container with very little oxygen in the water we find a marked rise during the first few minutes and then a very rapid fall ending in 30 minutes, in the particular instance shown here, in the death of the fish. Now we have the wild group, which is given in red. Starting in with lower respirations we get that initial increase and then a slower and more protracted fall. That is undoubtedly because the carp is a hardier fish and probably demands a lower oxygen level.

The third cause, among others, of biological changes is the action of toxic substances, and I am going to cite hydrogen sulphide gas in water as an illustration of that action. I am going to show you the difference between diminished oxygen and hydrogen sulphide action. Hydrogen sulphide absorbs, if you put it that way, some of the free oxygen in the water, and you also get the action of a diminished oxygen which is, however, overshadowed by the hydrogen sulphide action. Man and animals can breathe in a certain amount of hydrogen sulphide gas and show no toxic effects, but the minute we increase that we will say three times, from five parts in a million or six up to thirty, poisoning would result. Increase the dose still further and you get a paralysis of the respiration. However, the body has the ability to get rid of this poison very quickly, so it does not have a cumulative effect. You can give almost the lethal dose to an animal; the respirations will stop and the animal will be stretched out. Take him out of the gas and the animal will come to. Give him a second dose within a few minutes and the effect will be the same; you can give it to him many times. That is because the animal has the ability to change the hydrogen sulphide in the blood through absorption. In the same way you can take fish from water, put them in fresh water, bring them to, keep putting them back and forth and still maintain life. But while fish can stand a certain small amount of hydrogen sulphide, immediately when it passes the lethal dose there is a paralysis of the respiratory action followed by a partial recovery, then a gradual diminution resulting in the death of the fish. I will refer you again to the chart. I have taken the broken line as representing hydrogen sulphide, the black still being trout. The respirations were 80; in one minute after being placed in water containing hydrogen sulphide there was an immediate fall. In two minutes they returned to 30; then a rather quick fall, and in fifteen minutes, none. With the carp you get the same immediate fall; it passes down to zero; then you get your partial recovery, coming up in three minutes to 40, then

50, and finally passing down and resulting in death. The amount of hydrogen sulphide only corresponds to the initial dose—if I were to tell you what a dose was—because there is a constant diminution of the strength of the poison as the minutes pass. How is that to be applied to pollution and the problems connected therewith? There was a case in Lake Erie where many carp were killed by the material from paper mills. Now, the material from paper mills in itself does not kill fish—in this case there was nothing but the paper pulp. But that material settled to the bottom of the stream and there underwent fermentation and produced, among other things, hydrogen sulphide in very large amounts. By taking the water that came from these fermenting areas you could get a similar effect to that of the action of the hydrogen sulphide upon fish as shown in the laboratory. That is shown in the graph which you see before you. The dotted broken line is the rate of respiration of the fish held in sealed containers. The respirations would run between 80 and 90 in that particular temperature; then immediately the hydrogen sulphide fell down to four at one and zero at three. Then there was a slight rise and a subsequent fall. Now, what happened with the material from the fermenting substances? You get the same identical fall; you get your rise to a little more and a little slower fall—in other words, you have got absolutely the same curve. That was not due to diminished oxygen; it was due to the toxic action of hydrogen sulphide, because you got the same respiratory rate changes. Incidentally you got the same other changes, which we will not go into, in the rhythm and depth and character of the respiratory action.

There are certain variations that also have a bearing upon these questions which I mention. For instance, temperature; the colder weather requires a great deal more hydrogen sulphide to give the same effect upon the fish. Next, species of fish, for instance, trout, which require about eight or ten parts per million as compared with carp, 6.3 and goldfish, 25, with the same conditions of temperature. The goldfish in that case were the wild goldfish; the small aquarium goldfish require only about 4.3, but the large, wild goldfish such as are found in Lake Erie require a larger amount. This shows that the use of different species in your experimental work produces different results.

Discussion

DR. EMMELINE MOORE: It seems to me this is the most adequate presentation of the subject of the conditions requisite in experimentation of this kind that I have ever heard.

DR. BELDING: I am merely going to throw the next subject open for discussion. If anybody would like to make any remarks concerning the toxicity of certain chemicals such as acid, alkalis, salts and gases upon fish, I merely give the opportunity; otherwise I will pass over that subject.

MR. DOZE: We have a problem in that connection in the state of Kansas. At certain times of the year when we have heavy rains the flood water comes down off the chalk hills and alkali flats, runs into some of the streams and seems to kill practically all the fish in those streams. I am interested in knowing what measures Dr. Belding would recommend to overcome that condition.

DR. BELDING: I am afraid I cannot recommend anything, because my knowledge of curative measures in regard to polluting substances is rather limited. It is perfectly possible to have certain neutralization methods installed at the sources, where the polluting substance is entering the stream from a manufacturing concern or otherwise, but after the substance is once in the stream I do not know of anything that could be done. It would be dangerous to attempt any neutralization; you might do more damage than good. There must be in the audience, however, members who have had experience in the control of various forms of pollution and who might have some views to express on this phase of the subject. If not, we will pass to another topic.

We now come to the question of taking up a pollution survey, primarily for the purpose of obtaining information as to how much damage is being done in the streams or water systems and finding out definitely what the sources of pollution are, looking to the elimination or proper control of those sources. It resolves itself into the survey proper and the cataloguing of the information obtained, in such form that it will be available to those who require it. The survey itself is so bound up with the biological survey of the streams, such as is being made in various states for stocking, that the two have to go hand in hand; or the pollution survey may be made at the same time. We may be able to evolve some standard form for making pollution surveys, somewhat along the line of Dr. Embury's plan for New York, Massachusetts and New Jersey.

We have first the question of what would be a proper equipment for a person making the survey. Offhand, it appears to me that as this has to be a survey in general of the stream flow—a pollution survey—the person making it should have a map. That map should be ruled into squares, each of them numbered, in whatever form may be most convenient. Then he should have a notebook; and I have found in all our work that the most satisfactory notebook was a small book about 6 by 8, the pages ruled into small squares instead of merely lines or blanks. Each of these squares on the map could be enlarged on the right side of the notebook, and there you could make your diagrams of the stream, writing your information on the left hand page. That could be filed as a permanent record. The person making the survey

should also carry a camera. I am very firmly impressed with the value of pictures as compared with voluminous description. A man may write page after page of description which could be set forth much better and much more effectively and accurately by a well selected picture. Then, he should have a compass, in order that he might get the bearings; a thermometer; and perhaps some means of oxygen determination. Of course, the latter would involve the use of a bulky equipment and part of that work could be done in the field and the rest done afterwards, using samples brought in for the purpose. Then he would need certain collecting bottles, a dip net, and so on. We could go on with this subject indefinitely, but if anybody would care to make any suggestions at this point as to what might be considered valuable in making a survey, now would be a good time to make them.

PROFESSOR PRINCE: Have you found a convenient thermometer for efficiently testing the temperatures of depths?

DR. BELDING: The most convenient thermometer we have had is a maximum and minimum thermometer. They are a little bulky to carry, and they are also fragile. Our method was to take them out of the case and enclose them in a copper cylinder. They may also be protected by winding copper wire around them. Of course this is mostly stream work and you would not need a maximum and minimum thermometer as much as you would need a dip net. It would, however, probably be an advantage.

Inspection of Source. Here is a subject that will probably bring forth the expression of rival opinions. That is, how may the inspection of the source of pollution best be done? Briefly, you must decide whether to go to the establishment and ask those in charge to show you everything in an open and above-board manner. That is the method I approve. If there is any refusal on the part of the concern, or you feel that information is being kept back, other methods must be adopted. Before interviewing the manufacturing concern that is causing the pollution it may be well to take a brief survey of the stream in the vicinity so that you will know what questions to ask, and also whether you are being given correct and truthful answers. The line of inquiry you would probably take up would be that of the nature of the product that is being manufactured, the amount of waste, and so on. You would not merely want the volume of the flow coming in as compared with the volume in the stream—which would mean nothing. You would want the amount of waste material, not simply whether it was diluted with a great deal of water and put into the stream; you would want to know the actual amount of polluting material entering the stream. It is obvious, therefore, that it would not be sufficient to know what was the volume that came from the manufacturing establishment itself. The next thing you would inquire about would be methods of waste disposal. If there were any you would examine them with a view to seeing how effective they were. In intermittent pollution you would find your greatest difficulty. By intermittent pollution, which is very frequent,

we mean those instances where either by accident or by design large quantities of material are suddenly dumped into a stream, and then possibly for days, weeks or months no polluting substances enter. By accident I mean such an occurrence as the dumping of a carload, say, of acid into a stream. Naturally, of course, the owners or shippers would not in that instance want to lose so much valuable material. Sometimes such a thing does happen, as, for instance, when a carload of lime was dumped into a stream as the result of a railroad wreck. Where quantities of polluting substances are put into a stream intermittently it is almost impossible to get at the source of the pollution unless a man camps on the ground and is continually on watch. It is very hard to detect intentional intermittent pollution.

MR. HAYFORD: I would like to ask if Dr. Belding has any of his pamphlets printed in any quantity?

DR. BELDING: I have one here.

MR. HAYFORD: I simply wanted to say that we have a number of them left at Hackettstown and if there is anyone interested in taking up that work it will only cost him a postage stamp to send for one, and the result may be to save him from doing some of the work twice as we had to do in New Jersey. The first year we started out we got all the information we could, but it did not seem to be sufficient. So we had a little conference at Hackettstown—Dr. Embury, Dr. Belding, Professor Foster, Mr. Kitson and myself, and we corrected some of the minor mistakes we had made. I think we have covered every point with the exception of pollution, which, as Dr. Belding has indicated, is a rather difficult question. There was one instance in connection with our work which I think might be worth mentioning—that of a stream which to all appearances should be a very good trout stream. You could plant trout in that stream, but you could not catch one. So we made a little test, taking a stream near by as a control. We got some water from a bleachery in the vicinity and used it for the purposes of the test, and we found that the fish lived longer in the polluted water than they did in the stream water where apparently the fish should thrive. We observed also that the pollution was quite injurious to insects, whereas it was not harmful to the fish.

DR. EMMELINE MOORE: What kind of fish did you use for your test?

MR. HAYFORD: Two brook trout, two rainbow trout and two brown trout, each six inches in length, with exactly the same amount of water in each case.

DR. EMMELINE MOORE: Are you sure the pollution was running in at the time?

MR. HAYFORD: We got the water where the pollution was running in. It was taken out in two ten gallon milk cans.

DR. BELDING: The next topic will be that of Test Methods. I have listed four methods of determining the presence of pollution. One is the presence of fish. Now, that is the negative side; if the fish are present it might or might not mean that the material entering the

stream was harmful. The mere fact of the presence of fish would not prove that there was no pollution, and the mere fact that the fish were absent would not prove that the polluting material was entering the stream. The presence of dead fish would be very suggestive but not conclusive evidence, because fish may be killed by other causes. The popular method of fish baskets has been used. By that I mean putting minnows or other fish in baskets below the sources of pollution and seeing whether or not they survive. That sounds like a very simple and very effective method of detecting the effects of pollution. However, it seems to me to be open to some very serious objection. It has to be controlled by a similar test above, or it is not worth anything. You have to be very careful about the type of fish used in the fish baskets. You have to consider the flow of water, whether the fish are going to be jammed against the basket mesh or not, and that means care in the selection of the site and the placing of the basket. Another consideration is the fact that in some cases the waste material has no deleterious effect upon the fish as it comes freshly out of the mill or hatchery. So you have to consider a great many factors in coming to conclusions as a result of experiments with the fish baskets; it is not safe to say definitely that pollution is effective or non-effective simply because the fish die or live in the basket, as the case may be.

Chemical test for pollution. To me the ordinary chemical examinations for the determination of the purity of drinking water are worthless as applied to fish conservation. I think the most important test is probably that which relates to the oxygen demand—how much oxygen that waste is going to absorb in the stream. That can be determined and the results calculated. It is possible also that a determination of the acidity or alkalinity of the water may help in tracing certain acid or alkali poisons. There are certain floral and faunal indicators which have been worked out by Dr. Moore. I will ask Dr. Moore to say a word as to the various indicators in the animal and plant life that she has noted in the zones of pollution.

DR. EMMELINE MOORE: As you know, New York State had no machinery for testing pollution excepting the minnow test, which was depended upon by the inspectors and protectors to disclose conditions of pollution. The results were not always satisfactory, and we felt the necessity, therefore, of bringing together a kind of primer of pollution in which plant and animal indicators could be used. They would be more conclusive, since they would represent conditions at their worst. Plants and animals of certain types become adapted to these conditions and may therefore be used as indicators. Our publication illustrates them and gives other important information on the subject. It is a part of the eleventh annual report of the New York State Conservation Commission available for reference in all the larger libraries. We still have reprints in case members of the Society desire them.

DR. BELDING: We will now take up the general subject of fish distribution. The first phase of it that I wish to present is a new method

of studying fish environment and the suitability of waters for stocking. In the past the conditions which might be favorable to the fish in the matter of environment were obtained by direct observation. They found that the fish of certain species did well under certain conditions, therefore those conditions were the favorable ones for that particular species. I am going to try to outline for you a method based on the survey work described a few moments ago by Mr. Hayford, and in doing so I shall confine my remarks to one species of fish, the small mouth black bass. This species was introduced some sixty years ago in Massachusetts. It is found at the present time in about 269 ponds. We have made a comparative valuation of these ponds from the point of view of whether or not there is good fishing in them, taking into consideration the number of fishermen and the number of pounds of fish taken, and we have checked that as far as possible by following the results of stocking in certain of these ponds. By this method we have been able to grade the small mouth black bass ponds of Massachusetts on a percentage basis in terms of our best black bass pond. Each pond, therefore, has a percentage assigned to it, whether it is 50, 60, or 20, or what not, in terms of our best pond. We realize that an error of 10 to 20 per cent is very easy in this comparative calculation, so we have graded these ponds into four groups, A, B, C, and D,—A, those that run from 75 to 100 per cent—those are our best black bass ponds from the productive point of view— B, 51 to 75 per cent; C, 26 to 50 per cent; D, 1 to 25 per cent. Class A pond is where the black bass do well, whereas Class D pond is where the black bass exists but the conditions are not favorable for their development. It is possible that we have included in Class D ponds that may be favorable but in which, for some other reason, the black bass do not do well. On the average, however, we have in Class A the ponds where the conditions are best suited, so far as Massachusetts waters go, to the development of small mouth black bass, and in Class D the ponds where the conditions are just such as to enable them to survive. Then, we have taken the natural conditions of those ponds, based on survey work, and have contrasted a few of the conditions found in Class A pond to those found in Class D. These ponds are all over twenty acres in area. The first point we note is that the area is over twice as large in the favorable ponds as it is in the unfavorable; that the average area in acres is 185 against 85, and that the depth was 37 feet as against 20, taking the average. If we have regard to the maximum or minimum we find the same striking contrast.

Then, as to the water. We have grouped the water conditions into two, in order to simplify the comparison—light colored water, and water that is clear. We have noticed that in A the water was of a light color—89 as against 51 per cent—and it was clear in 56 as against 21 per cent. In other words, Class D had the darker type of water and the water that was more turbid. As to vegetation, whether marginal or submerged—bringing it down to the basic principle of differentiation—

we found that Class A had a smaller amount of dense vegetation—25 per cent—than Class D, which had 66 per cent. In other words, we have a shallower pond, a smaller area, darker or more turbid water, and more dense vegetation in D. You will notice that there is not the slightest difference between the inlet and the outlet in the two classes of ponds. Naturally there are a great many ponds in Massachusetts that do not have inlets or outlets, particularly on Cape Cod. As regards food, the calculation is based on relative abundance, and it was found that the average was slightly higher in D—44 per cent as against 37 in A. It will be noticed that mud bottom is more prominent in Class D ponds than it is in Class A. As to the shores, there is apparently no difference in their character. That gives us something to go by in the matter of stocking ponds with small mouth bass. It does not mean, of course, that we might not take individual ponds of Class A and make a failure, or that we might not take individual ponds that apparently came within Class D and have them prove a success. But if we took any number of ponds we would get much better results by planting the small mouth bass in A type than we would in the D type, and the difference is fairly clearly marked.

Temperature. I know that a number of you would like to discuss certain of these topics, such as area, depth, water, vegetation, food. I have added another topic here which seems to me most important of all, and that is, temperature, which governs the spawning of the fish, migration, food supply, growth, disease, toxic action, and so on. I will merely point out that certain bacterial diseases are controlled more or less by the temperature of the water—water below a certain degree of coldness inhibiting or holding in subjection the disease.

Toxic Material. We have already demonstrated that the fish become more resistant to the action of toxic material in colder water.

With your permission, Mr. President, I would like to have a discussion on any of the topics that I have just mentioned, including temperature.

MR. TITCOMB: I would like to ask Dr. Belding what would be the minimum area for a pond for black bass?

DR. BELDING: I can give you the minimum area on that work by reference to my notes; I do not remember it offhand.

MR. TITCOMB: While Dr. Belding is looking that up, may I say that I think there is a great tendency to stock small ponds and lakes with the small mouth bass and that as a rule you cannot expect satisfactory results in ponds of small area. The more northerly lakes—that is, around New England and that latitude—should be of even larger area perhaps than ponds further south.

DR. BELDING: In reply to Mr. Titcomb's question, I may say that 10 per cent of the ponds were between 21 and 50 acres in area; 15 per cent were between 51 and 100 acres; 12 per cent were between 100 and 150 acres, and 20 per cent were between 151 and 200 acres, making a total of 57 per cent that were less than 200 acres.

MR. TITCOMB: Would you consider, for instance, a 20 acre pond ordinarily suitable for bass?

DR. BELDING: No, I would not.

MR. TITCOMB: What would you ordinarily find suitable for bass?

DR. BELDING: Judging from these observations, our average would be just below 200. I should say, therefore, that the most suitable would be over 100 acres.

MR. TITCOMB: That is the point I want to bring out, because a great many people want bass in small ponds, where satisfactory results cannot be obtained. The United States Bureau of Fisheries is frequently called upon to stock ponds of small area in New England. In my own state I have had occasion to pass on applications for the stocking of certain waters with bass, and while I have not disapproved the applications I do not feel that in such cases I can recommend the introduction of that species. Now, in connection with this chart again—I do not know whether you want to discuss the large mouth in connection with this?

DR. BELDING: Anything you like, but I have no facts concerning the large mouth with me.

MR. TITCOMB: The question comes up whether your deep ponds of 85 acres, 20 feet in depth, with the dense vegetation and the larger amount of food, would not be more suitable for the large mouth bass.

DR. BELDING: In my estimation they would be suitable for the large mouth black bass.

MR. TITCOMB: That is the way I sized it up as I looked at the chart.

MR. WOODS: What other game fishes, if any, are found in these small mouth bass lakes?

DR. BELDING: Offhand, you might find pickerel, white perch if near the shore; yellow perch. In some of them you would find bullheads.

MR. WOODS: In Class D did you find large mouth also?

DR. BELDING: Yes, you find large mouth there too. They overlap.

MR. WOODS: What would be the live fish there for your large mouth bass? What would be the natural food? Would it be crayfish and things of that kind?

DR. BELDING: In Massachusetts the crayfish are found only in certain ponds. In one pond of type D crayfish are very abundant. It is a large, shallow pond. Crayfish are not so abundant in Massachusetts ponds as they are elsewhere.

MR. WOODS: Are these ponds stocked yearly?

DR. BELDING: That I could not answer. Perhaps Mr. Kitson can tell us about how many black bass they stock annually.

MR. KITSON: Possibly 25 ponds. That is just a rough guess.

DR. BELDING: There are 269 ponds that have black bass in them.

MR. WOODS: 200 acres, that would be a natural reproduction there.

MR. TITCOMB: In stocking these ponds with bass or in trying to maintain favorable conditions for the bass what other species would you encourage with them, such as perch, for instance, as food for the bass?

DR. BELDING: We have been stocking the smelt in certain of the lakes. That is practically the only food fish that we have been putting in. There are some objections on the part of the fishermen to putting in smelt. In Onota Lake, Pittsfield, the smelt has done very well, so much so that the fish have been impaired by their very abundance.

MR. TITCOMB: Is that a bass lake?

DR. BELDING: Yes.

MR. TITCOMB: Do the smelt live in the average pond of a depth of say 27 feet?

DR. BELDING: No, it is preferable to have a deeper pond for the smelt. In Onota Lake the depth is around 90, I think.

MR. ADAMS: I would like to mention one interesting feature there with regard to the food supply. It is a singular thing that the fishermen seem to be opposed to the placing of food fish in the ponds for the game fish to feed upon. During the last two years we have had alewives running into White Island Pond, perhaps one of the best bass ponds in the state, from the sea and spawn. Last year we had a fairly substantial number of young herrings in the ponds. That is to say, the alewives will run in in the latter part of April and through the month of May; they will deposit their eggs around the shore and then the adult fish return to the sea. The young fish hatch out and are anywhere from two to three inches long by the time the water begins to chill off in October, when they run out to the sea. The result has been that the whole lake has been well supplied with an ideal food for black bass, yet the opinion of the fishermen who frequent that lake is that the introduction of the alewives has been ruinous to the lake as a fishing and sporting proposition. They base their claim on the abundance of the food for the bass, thus destroying their game qualities. We have been petitioned, for instance, by the sportsmen to collect the adult fish and the spawn when the smelt run out of Onota Lake in the spring and spawn in the small tributary streams, in order that the smelts may be destroyed and that owing to a scarcity of food the fish will take the line in those waters. In between Middleboro and New Bedford there is a group of large, shallow lakes in which the bass fishing used to be excellent. During that time the alewives or herrings had access to those lakes, but since owing to changes in the general drainage scheme and what not the alewives are denied entrance to those lakes the bass fishing has been on the decline. We have had some very illuminating correspondence in the last six weeks on this very subject of food in the ponds from Dr. Lucas of the American Museum of Natural History. It is unfortunate that Dr. Lucas does not attend these meetings, for he has devoted a large number of years to the study of the food supply in the ponds. His contention is that the prime requisite in the building up of the fish supply in our ponds to-day is greater attention to the provision of a suitable food supply, running anywhere from the small shellfish and the shrimp up to the common forms of minnow life. In many states we are relying on the

smelt as a food supply for the ordinary pond fish. But the difficulty with the smelt is that it goes on shore to spawn in the spring, then as the water warms up it moves down to the bottom of the deepest holes in the ponds, with the result that during a substantial part of the year the smelt life is not available for many of the fish that are fed on shore. Looking at it, I will admit, in a superficial way, and not as a scientifically trained man, I am impressed by the fact that we must begin to take into account in respect to our fishing areas the same considerations that we have in mind in connection with our animal life on shore. I refer to the establishment of sanctuaries and areas that are particularly adapted for breeding purposes and where no fishing shall be allowed at any time of the year. A study should then be made to see what kinds of food, fish life or otherwise, can be put back into those areas as a food supply. This procedure would be based on the elementary principle that we cannot increase the numbers of fish in our ponds unless we can provide an ample food supply for them to live on.

MR. DOZE: I would like to have one point made clear. Small mouth black bass do better in mucky water than in clear water—is that true?

MR. TITCOMB: No, the other way. Class A is the small mouth.

MR. DOZE: "Color, light," is 89 per cent; "clear" is 56 per cent. What do you mean by clear? Do you mean clear water or light water?

DR. BELDING: In the standard method of stream examination as adopted by New Jersey, New York and Massachusetts, we describe water as white, light brown, and dark brown. Then we take the turbid water and classify that as clear, cloudy, muddy. For the purposes of my remarks I did not want to put that all down on the chart, so I merely said that the proportion of white and light brown water ran to 89 per cent in the ponds in Class A—lighter colored water—as compared with the 51 per cent in Class D, and the water was clear, did not show any cloudiness or muddy color, in 66 per cent of the ponds as contrasted with 21 per cent.

MR. DOZE: As to the vegetation, what kind do the bass prefer?

DR. BELDING: The small mouth prefer, I should think, a moderate amount of vegetation.

MR. DOZE: What kind of vegetation would that be?

DR. BELDING: There again we come back to the classification that we have adopted in the three states. This survey is made in a superficial way, because we have to cover perhaps an average of one and a half ponds a day. To make the classification as simple as possible we divided the vegetation into two general classes. First, there was the marginal vegetation; we merely classified that as none, scanty or dense. Then there was the submerged vegetation, out in the deeper water but where you can see bottom and get some evidence of it. That we classified as none, scanty and dense, the same as the other. I simply combine everything under the heading of dense or not dense, whether marginal or submerged; and 25 per cent of the ponds showed dense vegetation in Class A as compared with 66 per cent in Class D.

MR. DOZE: What would be the maximum temperature of the surface water in summer time in those ponds?

DR. BELDING: It would run into the seventies. Offhand, the surface water would be about 72. Of course, that would fluctuate with the temperature of the air, but I imagine that the summer average would be about 70 or 72. At the bottom it would vary according to the depth.

MR. WOODS: Have you a record of the edges of those lakes?

DR. BELDING: No.

MR. LEACH: The Bureau of Fisheries has tried to establish five acres as the minimum size pond that ought to be stocked with bass, but we have found that the size of the pond does not always govern the success of stocking. We have found ponds not over three acres that have been very successful in producing bass. It is also true that if you stock ponds of say 100 to 200 acres with a few thousand bass you are practically throwing away good material. If these ponds contain bass in any quantities and they are protected during the spawning season, they will produce more fish, manifestly, than the few you put in there; so, what is the use of putting a relatively small number of fish into a pond of that area? Protection is what is needed in that case. With regard to the smaller sized ponds, we have found, for instance, that a pond situated where it is surrounded by timber and must depend upon surface water for its supply is rather deficient in food. We have also found that ponds situated in the prairie states where the surplus drainage comes in through rain falls have a great deal more food. The ponds which I considered the most favorable are those which are fed from a creek. Quite a lot of minnows are brought into ponds of this kind and the bass will live on them without any artificial or natural food. In those cases, therefore, where shiners or small minnows are provided as food it is necessary to make a study, in turn, of the foods which are necessary to the existence of the small fish on which the bass feed. Shiners will not live in a pond which is deficient in the foods which they require. This is a study which the states are more fitted to take up than the bureau. In Massachusetts, Pennsylvania, New Jersey and quite a number of the other states this problem of producing natural food is being taken up. The bureau, of course, found it necessary on occasions to stock these smaller ponds, because in some sections of the country a pond of five acres would be a lake of considerable size, whereas down in Massachusetts and some other states where they have 100 and 200 acre ponds they would look upon a 5 acre pond as a mere swimming hole. Then, of course, the question of politics comes in. Someone will want some fish for a three acre pond; the people may oppose it, and the bureau may not recommend it, yet the applicant may have sufficient influence to get the fish anyway.

MR. WOODS: Mr. Leach makes reference to a five acre pond being one of considerable size in some districts. Does he mean a considerable size for large mouth or small mouth black bass?

MR. LEACH: Either one. But we would rather put in bream, or some such fish as that, because the food of the bream is different from that of the bass.

MR. TITCOMB: I am glad Mr. Leach brought up that last point, that he would rather put fish of smaller growth into those smaller ponds. But when he speaks about being successful with bass in a five acre pond, I am wondering whether he means merely that he furnished a can or two of young bass for such a pond which had been devoid of bass, and got results, or whether after getting the pond stocked with bass it continued to produce satisfactory results.

MR. LEACH: Every three years we write all the applicants who received bass and ask them what per cent they have obtained. We ask them to give the size of the pond and a general description of it, and the information thus obtained shows that in ponds of five acres and over the proportion successfully stocked has been 70 per cent. That is, stock placed in ponds constructed for the purposes of a fish pond has been maintained; the fish maintain themselves by spawning one season after another and produce results which are perhaps sufficient to meet the needs of the farmer concerned or of his friends; the waters were considered well stocked. In Washington we recently leased some goldfish ponds, out near Lakeland, College Park. Some of these ponds contain five acres, some eight; I think the largest contains about ten. Last year we stocked the five acre pond with about fifty fish, the eight acre pond with something like seventy-five and the ten acre ponds with perhaps one hundred or so. From that we produced over 35,000 little fish in October for distribution, ranging about three and a half inches in length. These ponds are all fed from creeks. It is a spring fed stream but it runs through a lot of land from which it gets a good deal of drainage, and it is well stocked with insects and minnows.

MR. TITCOMB: I think we should differentiate between ponds used as breeding ponds and ponds which are stocked for the public benefit. Evidently Mr. Leach, in speaking of these five acre ponds, is referring to privately owned waters in which, of course, only a limited amount of fishing would be done. Dr. Belding's discussion has reference to the stocking of waters for the benefit of the public at large. Personally I would not encourage the stocking of anything less than 100 acres except under very unusual conditions—I am referring now to small mouth bass—where the public are going to get at it and fish intensively as is done in New England.

MR. DOZE: In the southwest we stock ponds as low as an acre and we get very good results. I happened to visit a pond a couple of weeks ago the area of which is about an acre and a half; we fished about twenty minutes and we got one four and a quarter pound bass apiece, one three pound bass, one weighing probably one and a half pounds, and two bluegills, and we threw back two small large mouth bass. In our country, where a 100 acre lake is a rarity, it would be very discouraging to adopt a policy of not giving the people bass. The large

mouth bass seem to thrive there. We have stocked creeks where the pond areas would be no larger than this room, but connected up with a little running stream. The size of the pond would be related also to the climatic and geographical conditions, and also the food conditions. It may be true that we should have larger ponds, but I want to enter a protest against a policy of only stocking lakes of 100 acres when we stock them successfully as low as one acre in area.

MR. ADAMS: I think the discussion is getting a little off the track. I suggest that we defer any general discussion on the propagation and handling of bass until we hear Mr. Beeman's paper on Thursday morning, on "Habits and Propagation of Small Mouth Black Bass," and that this discussion continue on the general principle of fish distribution, which, I understand, is really the objective of the paper now being presented.

DR. BELDING: Before I take up the last subject, may I say that your small pond of Class D condition might for some other reason be satisfactory. But the average type A pond would be a satisfactory pond and the average type D pond would be an unsatisfactory pond. In other words, we are speaking not of the individual ponds, but of the average.

The final topic is entitled, *Stocking Antagonistic Species*, that is stocking the same waters in the same stream system with two species. I will use as an illustration the brook trout and the brown trout. I will not burden you with any facts about the two species of fish, because you know them better than I do. A number of our brook trout streams in Massachusetts which were formerly good, no longer have trout in them; because of the changed conditions, due to civilization, etc., they cannot now produce brook trout satisfactorily. Now, it is possible to put brown trout in those waters, with successful results, yet we do not want to harm any of our brook trout streams by doing that. I am going to use a further illustration, the Westfield River in Massachusetts in order to show you how both species may be planted with the least damage to one or the other. There are a total of 117 tributary streams running into the three branches of the Westfield River. Of these 30 are good brook trout streams at the present time; they would be classed as A or B. Now the problem comes in, how can we plant brown trout without having the two of them together, and how are we going to plant them with minimum disadvantage to our good brook trout streams? We do not care anything about the remaining streams—the difference between 30 and 117—because they are no longer good for brook trout. The question of dams comes in; there are ten dams which might possibly afford us help. I have designated on the chart in red the three dams below which it is safe to plant brown trout, the only risk we run being that some of the brown trout might be carried over. That risk, however, is only very slight, so that by planting brown trout below the points indicated by red marks we run the risk of injuring 18 of the 30 streams, and at the same time we possibly benefit the difference between 30 and 117, which is 87. So that where there are a sufficient number of dams

on your river systems, as there are in most of the Massachusetts streams, by reckoning the value of the brook trout streams under present conditions you may be able to determine where brown trout may be planted without detriment to the brook trout. This is merely an illustration of one river and one species of fish to bring out the fact that a study of the local conditions in any particular stream or body of water may be carried out with a similar end in view.

MR. TITCOMB: I do not think it is necessary to call attention to the importance of guarding against getting the brown trout into good trout streams, unless you are willing to sacrifice one or two streams in the system, as Dr. Belding has suggested. I have found that when you put the trout into the main waters of a native trout stream, the water being cold and the stream heavily shaded, the trout you put in may ascend some of the small tributaries and clean out the natives. You will occasionally find a stream in connection with your survey which is heavily wooded, which has a lower average temperature in the summer than the ordinary trout stream, and where the brown trout will not go, and you can eliminate that stream and consider that you continue to have it as a native trout stream.

MR. LEACH: When brook trout are put into a stream they will seek the head waters; they will find colder waters than the brown trout. That has been our experience in western streams and also in certain northern streams. A stream is stocked with trout for either one of two purposes. It is stocked for the sport fisherman, in which case the brook trout should be provided, or for the fishing public, in which case you would probably stock it with the fish which would maintain itself best in that stream. If you can only get 30 or 40 per cent efficiency in the streams with brook trout, you can probably put in the brown trout, or Loch Leven, and get 70 or 80 per cent. If the brook trout are not doing well I believe a change should be made, regardless of the fact that sportsmen are opposed to brown; I believe you ought to put in the trout that will give the best results to the fishing public.

MR. TITCOMB: I suppose in such a case you would refer the matter to the commissioners in the states before taking action?

MR. LEACH: I would.

NOTES ON THE CONTROL OF GYRODAC- TYLUS ON TROUT.

BY GEO. C. EMBODY,

Cornell University.

In the Twelfth Annual Report of the New York Conservation Commission for the year 1923, Dr. Emmeline Moore described the fin disease of trout and gave two excellent photomicrographs of the causative agent, a flat worm called *Gyrodactylus*.

Through the courtesy of Superintendent Charles O. Hayford, the writer had an opportunity to study the work of this organism in the New Jersey State Hatchery at Hacketts-town.

The parasites were first observed in late August, 1923, on the fins of yearling brook trout 5 to 7 inches long. Although the smaller fingerling trout were examined carefully at the time, they were found to be free from the organisms.

Early in February, 1924 an examination of the trout in various ponds disclosed a heavy infestation among all brook trout and a light one among the 3 to 6 inch rainbows and browns.

The mortality among the brook trout jumped from an average norm of about .16 per cent per day to a peak of 1 per cent per day, that is from about 8 fish in 5,000 to 50. In case of rainbows and browns no increase in losses was evident.

Several 3-inch bullheads which had been kept in the trout ponds were likewise badly affected and in early July of the present year (1924) both large-mouth and small-mouth black bass 1-2 inches long showed parasites. In the latter case, however, no losses were observed and by the first week of August, parasites could not be found in the bass ponds.

The brook trout mentioned above had been kept in spring water having a temperature of about 51°F. A lot of several thousand were transferred to a pond supplied with creek water which in February was only a few degrees above freezing. The colder water did not check the disease but seemed rather to decrease the resistance of the trout.

It is thus evident that brook trout are very susceptible to this disease at temperatures ranging upward to 51°F., and that serious consequences may result, if proper control measures are not resorted to.

A number of materials were tried experimentally in order to devise a method of control. Among them may be mentioned gasoline, common salt solution, copper sulphate solu-

tion, dilute sulphuric acid, mixtures of lime and water, chloride of lime and water, vinegar and dilute acetic acid.

A one minute immersion in gasoline killed many but not all parasites. A great many of the trout, however, were seriously affected by this treatment and it was discontinued.

A 2½ per cent salt solution had no effect upon the parasites.

Immersion in .5 per cent copper sulphate solution for a period of five minutes likewise was not effective.

A .05 per cent solution of sulphuric acid in water killed the worms instantly and seemed not to affect the trout after a 15-second immersion. However, the after effects of dilutions of sulphuric acid upon trout are not well known and until these have been studied more carefully, this method of control is not recommended.

If unslacked lime is stirred in water and allowed to settle, the clear liquid kills *Gyrodactylus* in one minute.

Likewise if a small quantity of chloride of lime is stirred in the water the same way, the clear liquid is effective in 20 seconds.

During the 1923 meetings of this society, the writer was informed by Mr. Charles A. Bullock of the U. S. Bureau of Fisheries and again by Dr. Emmeline Moore that vinegar had been used successfully for controlling the disease. And Dr. H. S. Davis has lately told me that it was the late George A. Seagle of Wytheville, Va., who probably first used vinegar for this purpose. A mixture of one part of vinegar to twenty parts of water was found to be entirely successful after a one-minute immersion. This was when standard vinegar containing 4 per cent acetic was used. However, it was found that vinegar varied in its acid content and a mixture of dependable strength could not be made from the ordinary commercial brand. Since the effective ingredient in vinegar was acetic and acetic acid of definite strength could be obtained of any druggist, it was thought, that a standard dilution of glacial acetic acid could be made which would be dependable at all times.

Consequently tests with acetic acid of various strengths were first tried upon isolated parasites and then upon affected living trout. It was found that a .2 per cent solution killed *Gyrodactylus* in 15 seconds, if thorough contact was had and that brook trout fingerlings and yearlings were not noticeably affected by the acid after a 2-minute immersion. Likewise a .3 per cent solution killed the parasites in a somewhat less time and did not affect the trout adversely after an immersion of 1½ minutes.

It was an easy matter to treat a few trout at a time but when as many as 200 were so treated, difficulties arose. Such a large number could not be dumped into a tub containing the liquid with a degree of safety, because all could not be removed at the same time.

The trout were then placed in a dip net which could be speedily immersed and withdrawn just as speedily. Another difficulty arose. A few of the parasites were found to be partly embedded in the mucous covering of the fish and it required a somewhat longer immersion to obtain a thorough penetration of the liquid. It was also noticed that there was a tendency for the bodies and fins of many trout to remain more or less protected by those of neighboring trout due to the over-crowded condition of the net. To overcome these difficulties a net with a roomy bag was used and the duration of the treatment was prolonged.

The following procedure has given uniformly satisfactory results:

A solution containing .2 per cent acetic acid is made by adding one part of glacial acetic acid¹ (99 per cent) to 495 parts of water. This is placed in a wash tub, hatching trough or vat of appropriate size. An ordinary wash tub one-half full is generally enough liquid to treat 1,000 trout 3 to 6 inches long.

A dip net with a ring about 1 foot in diameter and a bag that will stretch nearly to the diameter of the tub, is used for holding the trout during treatment. From 150 to 200 trout may be submerged in the acid solution at one time.

The first four lots remain in the liquid for 1 minute; the next three lots remain for 1½ minutes, and the last three out of the thousand remain 2 minutes.

The necessity for this variation in the duration of the treatment comes from the dilution of the acid solution by water which adheres to the fish and net and is added to the tub every time an immersion is made. This cannot be wholly prevented and consequently the treatment must be prolonged as the acid solution becomes weaker.

The trout are then returned to a pond which has been thoroughly cleaned and if possible sterilized with lime or chloride of lime.

Ordinarily a single treatment will suffice, if it has been done thoroughly and if the pond has been sterilized. Otherwise it may be necessary to follow with a second and sometimes even a third, before the disease is controlled. The interval between two treatments will rarely be less than two weeks.

¹ Some druggists carry 36 per cent acetic acid. To make a .2 per cent solution from this take 1 part acid to 180 parts of water.

Discussion

MR. ADAMS: Will Dr. Embody state briefly what the fish look like when they are attacked by this parasite, and what is the progress of the disease?

DR. EMBODY: To determine what the trouble is you have to use a microscope or magnifying glass of rather high power. You cannot always diagnose the trouble by the external appearance of the fish; the only sure way is to look for the germ itself. But the trout often show a whitening of the fins.

MR. ADAMS: Is that confined entirely to the fin?

DR. EMBODY: Yes, but the parasite has been reported also on the gills. I have never found any on the gills.

PROFESSOR PRINCE: It is a fresh water form.

DR. EMBODY: Yes.

PROFESSOR PRINCE: I have observed a species occurring in salt or brackish water. It is rather a pretty worm, and I was wondering whether it was a different species I had seen. With respect to Mr. Adams' question, I think the fin does look a little changed; it begins to look thinner. There is indication of something wrong with the fins, the pectoral and caudal fins especially. Perhaps Dr. Moore could tell us whether more than one species has been noted.

DR. EMMELINE MOORE: I think that in Dr. Hofer's *Fishkrankheiten* there is a description of another. It is a little smaller in outline than the one I described. May I ask how Dr. Embody would treat a pond very heavily infected with this *Gyrodactylus*?

DR. EMBODY: I know of no other way than that of taking a net, getting your fish out in a tub, then dipping out a handful at a time and immersing them in the solution. Then put them back in a tub of clean water. In the meantime, you would sterilize the pond.

DR. EMMELINE MOORE: How would you treat the pond?

DR. EMBODY: I would sterilize it. A very handy thing for that purpose is chloride of lime. It takes only a little to kill everything in the pond.

DR. EMMELINE MOORE: I suppose the organism exists in various forms in the earth and dirt around the pond?

DR. EMBODY: I cannot help but believe it does, though I have no positive evidence of it. I examined material in the bottom of the ponds; I scraped a good deal of slime from the sides, but I found only one parasite, and it was dead. The evidence, therefore, is all negative.

MR. LEACH: In treating fish for *Ichthyophthirius* in Washington we put the fish in a tile-lined trough with a pretty strong flow of water with a syphon arrangement at the foot to drive the water down and cause a strong suction. We found that by this method in about a week or ten days we could free the fish of the parasite. Of course they drop off after a certain time, and if the water is quiet water they separate and form into innumerable parasites, and then reform on the fish. As

soon as they drop off the fish in these tile-lined troughs they are carried away by the action of the syphon and the fish naturally free themselves. I was wondering if it would be the same with this other parasite.

DR. EMBODY: I am not so sure. We know very little about the life history of this *Gyrodactylus*. Those few forms that were taken off the living fish did not live very long. Whether it was due to the conditions in respect to the vessel in which they were kept I cannot say, but those we were working with would not live very long away from the fish. It is a mystery to me; I am sorry I did not have more time to follow it out more carefully, especially the life history of the organism. That running water treatment for *Ichthyophthirius* we found to be very effective. We had a bad case of that, or a closely related form, at our university hatching station. We treated the fish with a salt solution first; in fact, we used copper sulphate also, and alum, as recommended by the Bureau. The alum did not work so well as the salt.

MR. LEACH: We had to sterilize the tanks with lime, about a ten per cent solution. We also found that we could hasten the departure of the *Ichthyophthirius* from the fins by painting them with a solution of carbonate of soda, using a paint brush.

DR. EMBODY: Did that parasite give much trouble?

MR. LEACH: It attacked a great many of our fish.

DR. EMBODY: We had no trouble beyond the green stage. Our worst trouble was with the little fellows an inch or an inch and a half long.

MR. LEACH: It would get on the members of the bass family until they would turn white.

DR. EMBODY: We did have trouble, though, with a closely related form—*Chilodon*. We found in connection with some of our work that in the hatchery troughs where the temperature of the water went down to 33 or 34 and remained that way during the greater part of the winter the fish were all right until they struck the lower temperatures; then they gradually succumbed to this trouble. The fish recovered in the case of this particular protozoan, even at that low water temperature.

MR. TITCOMB: I would like to inquire whether those who have been keeping in touch with these diseases have learned the causes of them and can recommend any way of avoiding them?

DR. EMBODY: I think that is a question for Dr. Davis to answer.

DR. DAVIS: The only way to avoid it is to get rid of the parasites. You will never have trouble with *Ichthyophthirius* where you have a good circulation of water. It is only in small ponds and aquaria where there is not a proper circulation of water that you have trouble. The best thing to do is to put your fish in running water.

MR. TITCOMB: How about *Chilodon*?

DR. DAVIS: I have never seen cases of any particular trouble from *Chilodon*, but I do not know that the same treatment would be equally effective.

MR. TITCOMB: How about *Gyrodactylus*?

DR. DAVIS: It does not work at all in *Gyrodactylus*.

MR. TITCOMB: Is there any way to avoid that?

MR. DAVIS: Use vinegar and acetic acid. I have seen trout badly affected with *Gyrodactylus* in a small cement pond where there was a good circulation of water.

MR. TITCOMB: With a low temperature?

DR. DAVIS: Well, about 50.

MR. HAYFORD: I was interested in Dr. Davis' statement that he had not noticed *Ichthyophthirius* in ponds where they had a good circulation. Since we first had trouble with that parasite I learned how to use the compound microscope and we now have no difficulty on that score. The ponds in which they gave me trouble were seven by fifty, containing two or three feet of water, with a temperature of 62 and a volume of 7,500 gallons of water going through.

DR. DAVIS: You are sure that was *Ichthyophthirius*?

MR. HAYFORD: Well, it was a man trained in the United States Bureau of Fisheries who identified it. I came in contact with many interesting things in that connection; it really was the means of making me have more respect for the scientific mind. That was twelve years ago, and up to that time I had never realized the value of the scientific mind, but since then I have become more and more impressed by the value of scientific work in this connection. The only salvation of the American fish culturist to-day is to utilize the services of the scientific man. If he is fortunate enough to have men like Dr. Embody and Professor Foster working with him, as I did, he has got to be at least thicker than I am if he cannot pick up a few points and learn to recognize most of these species after having them explained to him.

MR. LEACH: This *Ichthyophthirius* is a peculiar bug, if you can term it a bug. In Washington we have one of the best water supplies in the country. The water is brought from the Potomac River, is filtered and treated with chloride of lime, and it comes into our aquaria perfectly clear. But even at that, for some unknown reason, this parasite will get started and the only way we can clean it out, as I said before, is to treat every tank with a solution of ten per cent lime. Our tanks are lined with rock, of course, at the back, but in the woodwork the *Ichthyophthirius* will linger for years. It will not develop until the water temperature gets around 48 to 52 degrees—at 52 it seems to develop much faster than at lower temperatures. When you get the water down to around 46 you are not bothered much with it; at least it does not seem to interfere with the fish.

DR. EMBODY: We find that the *Chilodon* produces its greatest mortality at temperatures running around 33 or 35.

THE TRANSMISSION OF OCTOMITUS SALMONIS IN THE EGG OF TROUT.

BY EMMELINE MOORE,

New York State Conservation Commission.

Although a paper on *Octomitus* has become thus far an annual event, this being the third of the series, it is not intended to engraft this subject upon the program as perennial stock. Special interest, however, attaches to this further discussion because of its bearing on cultural methods and policy.

The phase in the life history of *Octomitus* which I shall discuss is related to the mode of transmission of the organism from fish to fish. I may over-sanguine but I believe we have come to the point where we can supply the key to the mystery surrounding the source of infection by this organism, and to go a step further, to explain the causes of early and belated epidemics of octomitiiasis.

In a previous paper I referred to the presence of the organism in the blood, and the possibility of its conduct by this means to all parts of the body. In the more recent studies it seems that the blood is more than a carrier, it is actually a generator of the organisms in their minutest stages, in which almost infinitesimal forms arise out of repeated divisions.

The blood in the region of the kidney seems most abnormal and suggests the possibility that this organ is a retreat, as it were, from which the organism may emerge with renewed activity, and be carried to congenial tissues through the medium of the blood.

Practically all soft tissues in the body are penetrable by the organism. The brain may suffer an over-whelming invasion, the destruction of tissue in these parts being evidently associated with the occupancy of the nucleus by the organism. Further growth and division proceeds and the second crop of juveniles, larger in size than those emanating from the blood corpuscles, seems destined to migrate still further before passing the final stages of adulthood. The congestion in the brain is naturally correlated with the whirling symptom which commonly distinguishes this disease in the final stages preceding death.

Of the high concentration of the organisms parasitizing the cells lining the ceca and fore-intestine, mention has been made in the previous papers. Suffice to say by way of reiteration that in the lumen of these organs the adults find a favorable medium for swarming in the excessive mucous

discharges accompanying this disease. Spores develop there and passing from the body become dispersed in the water. Mention has been made also that adult fish remain carriers of the organisms though often seemingly unaffected by them.

In carriers the histological studies of the gonadal tissue disclose definitely and clearly the phenomenon of parasitic castration. The actual destructive effect in the invasion of the sexual glands by *Octomitus* seems to the naked eye less marked in the ovary than in the testes where more or less complete emasculation and atrophy of the organ may take place. Presumably, all of the white or dead eggs in an infected ovary are those damaged either by the invasion of the parasite directly or by the interruption of nutrition through its activities.

The next logical step in the pursuit of the parasite was to follow it in the successive stages of egg development, e. g., in the unfertilized and fertilized egg, in the embryo and the sac fry stages. In each there appears an invasion of the yolk material by *Octomitus* in a most remarkable manner by a plasmodium-like body composed apparently of an aggregation of exceedingly minute juveniles. This body encroaches on the yolk material from the periphery in close proximity with the blood stream and penetrates into the yolk by a process of digestion presumably through secretions from the organism.

That the egg should be a carrier seems reasonable to expect from the conditions of parasitism existing in the reproductive organs. Yet an organism so plastic in nature as *Octomitus* offers a stubborn challenge in the matter of interpretation. The links are by no means definitely connected in the histological studies and resort was had to culture methods.

By inoculating media with blood drawn from an infected fish, with spores, with adults, and with the yolk material of eyed eggs taken from infected brood stock, the same end points were reached in each case. That is, minute juveniles were obtained in the cultures which conform with these structures as noted in the histological studies. It was not possible to grow the organisms to the adult stage yet positive results were obtained along many lines particularly in the explanation of conditions in the blood and in the interpretation of the plasmodium-like invading body. In passing, it is important to mention a word about the viability of the spores. Where old spores were used as inoculating material they had been dried for six months. That shows how essential it is to take precautionary measures about

hatchery premises in the matter of disposal of diseased fish.

It has been observed that epidemics of octomitiiasis occur either early in the sac fry stage or later after the fingerlings have attained some size. With the incidence of infection two-fold, one by way of the egg and the other via infectious spore there is good reason for believing that epidemics of octomitiiasis occurring early are traceable to eggs derived from infected brood stock, in the sac fry stage or shortly thereafter, and that later epidemics among older fingerlings originate by the ingestion of infectious material through the alimentary tract.

In conclusion it seems hardly necessary to point out the need of clean brood stock and the necessity of extending investigations to include a more critical inquiry into the source of our egg supply.

THE INTESTINAL PROTOZOA OF TROUT.

BY H. S. DAVIS,
U. S. Bureau of Fisheries.

It is a well known fact that the alimentary tract of animals, both vertebrate and invertebrate, harbor a great variety of living organisms. Many of these are harmless commensals and some, as in the case of certain bacteria, may actually be beneficial. On the other hand many species have been shown to be more or less harmful while others occupy a peculiar position in that ordinarily they seem to have no injurious effects on the host while at other times they may be the cause of serious ailments. As can readily be understood it is often difficult to distinguish between the friendly and harmless denizens of the digestive tract and those which are the actual or potential foes of the animal whose intestinal accommodations they may have monopolized.

During recent years one group of the inhabitants of the digestive tract of man and other mammals has been much in the lime-light and received special attention from parasitologists. I have in mind the unicellular animals known as protozoa of which a goodly number are known to find congenial quarters in the intestines of various animals, both high and low in the evolutionary scale. It is not surprising, therefore, to find that trout and other fish have their share of these unwelcome guests, although until recently they have received very little attention. Chief interest has centered around the flagellate which Dr. Emmeline Moore, in a paper presented at a former meeting of this society, christened *Octomitus salmonis*, and which is, in all probability, the cause of serious injury to the young fish. While this is the only intestinal protozoan parasite of trout which we have reason to believe is of economic importance it is necessary for various reasons to consider the other protozoan inhabitants of the intestine in any investigation of the disease known as octomitiasis. During the writer's studies of this disease, which have been carried on since the spring of 1922, it has been found that there are at least three other protozoan parasites more or less common in the digestive tract of trout. One of these is a flagellate closely related to *Octomitus* which so far has been found only in the gall-bladder and appears to be confined to this organ. There is no evidence that it injures the host although it is sometimes quite abundant.

In addition to the flagellates there are at least two species of amebae, one of which is very common in the stomach,

although in spite of its abundance it appears to do little if any harm. This ameba is of considerable interest from the scientific standpoint since it differs radically in many ways from the intestinal amebae occurring in other animals. It can often be found in large numbers crawling slowly about over the epithelial lining of the stomach. Each individual has from one to several nuclei and in several respects appears quite unlike most intestinal amebae. But the most striking characteristic of this species is the formation of large multinucleate cysts which have been thought to be the cysts of *Octomitus*. This mistake is but natural since both are usually found together in the intestine of infected trout. But the fact that these cysts are formed in the stomach is of itself sufficient to show that they can have no relation to *Octomitus*.

The other species exhibits the characteristic feature of parasitic amebae so common in many vertebrates, but since it occurs but rarely little is known of its life-history, and there is no reason to believe that it is detrimental to the host.

Since, as previously stated, only *Octomitus salmonis* appears to be of economic importance this species has received the most attention and it is now possible to present a fairly complete account of the life-history, although I find myself unable to agree in several respects with the account given by Dr. Moore at the last meeting of the society. Only a brief summary of the more essential features of the life-history can be given at this time and these I have attempted to bring out in the accompanying diagram (Fig. 1).

One of the most striking features of the life-cycle is the fact that the parasite appears to go through two quite different stages in the course of its development. One, the intracellular, is confined to the epithelium of the pyloric caeca and the interior end of the intestine, while during the other or flagellated stage the parasite is found swimming actively about in the fluid contents of the intestine.

The youngest form of the intracellular stage is a small rounded cell with a single nucleus which occurs within the epithelial cells lining the caeca. They grow rapidly to many times their original size and soon divide into a number of small rounded cells, similar to the original, which in their turn invade other epithelial cells. Under certain conditions the intracellular parasites may multiply very rapidly so that a large percentage of the epithelial cells become infected. After a time some of the parasites, instead of dividing again, undergo a quite different course of development and eventually assume the typical flagellated form

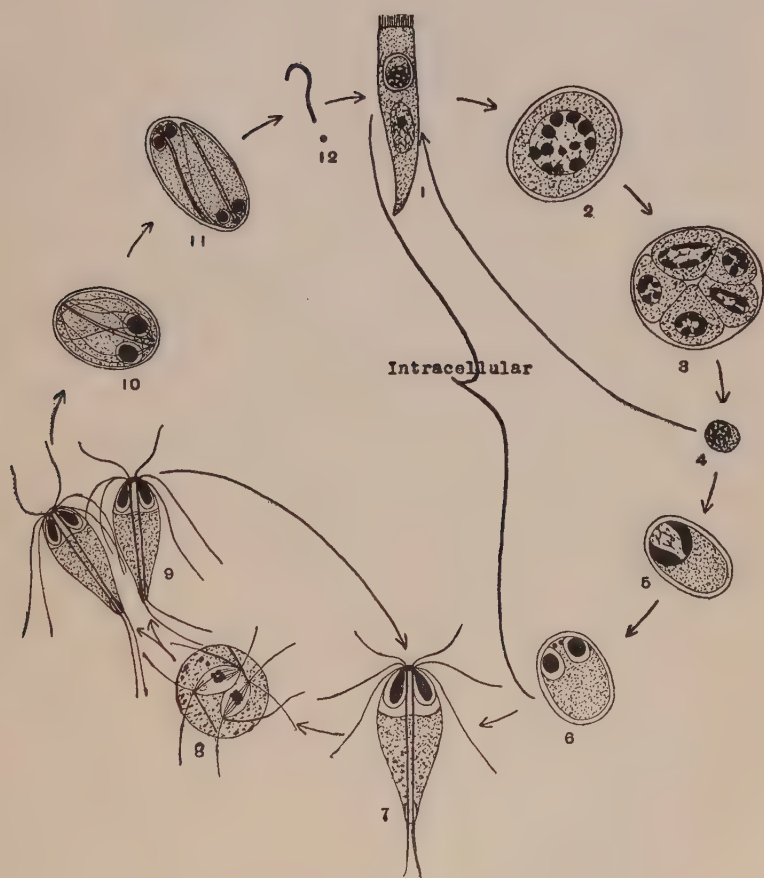


Fig. 1. Diagram showing the life cycle of *Octomitris salmonis*. Figures 1 to 6 represent the intracellular stages which occur in the epithelial cells of the pyloric caeca. The remaining stages, 7 to 11, are found in the lumen of the intestine. The intracellular forms divide into a number of small cells or sporozoites which may again enter epithelial cells and repeat the process or they may develop into the free-swimming flagellated stage as shown in figures 5 to 7. The flagellates may multiply by binary fission (7 to 9) or they may form cysts (10 and 11) which pass out of the body in the excrement and are presumably ingested by another fish.

which soon makes its way into the lumen of the intestine. While the flagellated form, with its paired nuclei and four pairs of flagella, is very unlike the intracellular stage there is good reason to believe that they are simply different stages in the life-cycle of a single organism.

Like the intracellular stage the free-swimming flagellate may under certain conditions increase very rapidly, but in a quite different manner. Multiplication at this stage is accomplished by a process known as binary fission during which, as shown in the diagram, the flagellates become rounded and the various cell structures, with the exception of the flagella, divide into two equal parts. This process requires but a short time and at its termination there are two flagellates where before there was but one. New flagella are quickly developed so that the daughter flagellates are identical with the mother in every respect but size.

The spread of the parasite from fish to fish is probably accomplished by means of cysts which are sometimes very abundant in the intestines of infected fish. Only one type of cyst has been found which is very different in appearance from the ameba cysts already referred to. They are ovoidal, rarely spherical, in shape and at first contain a single flagellate which is surrounded by a thin transparent membrane. The organism retains its flagella for a short time after becoming encysted but later these are lost although the paired nuclei, blepharoplasts and axostyles are retained. Shortly after the disappearance of the flagella the enclosed organism divides into two as shown in the diagram, each one with paired nuclei, blepharoplasts and axostyles. Following this division the cysts become elongated and the two daughter individuals appear more distinct being often found with their anterior ends at opposite ends of the cyst. Unfortunately, it has not been possible to follow the development of the cysts beyond this stage but it is probable that after reaching the exterior they are accidentally ingested by another fish, and passing to the intestine set up a new infection. In this they are aided by the tough, resistant membrane surrounding the cysts which no doubt enables them to withstand without injury conditions which would quickly kill the flagellated form.

Having briefly considered the life-history let us turn to the effects of the parasite on the host. Here we find that the evidence is in some respects quite contradictory and I can only give you the tentative conclusions which have been reached after more than two years experience with the parasite at a number of hatcheries in different parts of the country. In the first place it must be clearly recognized

that a trout may harbor great numbers of the parasite without apparently being seriously inconvenienced. This does not, however, necessarily mean that it is a harmless commensal as has been claimed by Schmidt to be true of a closely related species in European trout. In judging the harmful effects of *Octomitus* we must take into consideration the condition of both the parasite and the host. Anyone who is familiar with the phenomena of infectious diseases, especially those due to protozoa, must realize that because a parasite is apparently harmless under certain conditions it does not necessarily follow that it is equally innocuous under other conditions. So in the present instance we find that while ordinarily trout over four inches or so in length show little or no ill effects, even when the parasite is abundant in the intestine, younger fish may exhibit every evidence of malnutrition under the same conditions. In other words it is believed that the presence of large numbers of the flagellates in fingerling trout up to three or four inches in length may seriously interfere with their nutrition causing them to become thin and emaciated forming the so-called "pinheads" so familiar to fish culturists. Far be it from me, however, to hold that all "pinheads" are due to *Octomitus* since it is evident that anything which interferes with the nutrition of the fish will tend to have the same effect. This form of octomitiasis is undoubtedly common at many hatcheries and while not usually accompanied by serious mortality does much harm by interfering with the normal growth of the fingerlings.

But on the other hand there is reason to believe that serious epidemics, accompanied by heavy mortality, can be traced to *Octomitus*. Why the parasite should at one time produce a chronic wasting disease and at another an acute infection with high mortality is difficult to understand, but it is believed that the explanation lies in the two distinct stages in the life-cycle. Ordinarily the intracellular stages are not abundant but under certain conditions they may increase very rapidly so that in a short time a large proportion of the epithelial cells may be infected. As a result the intestine and caeca become congested and patches of the epithelium may be destroyed. Such a condition, of course, quickly results in the death of the host.

My attention was first called to this parasite by the fact that the fingerlings from certain of the bureau's hatcheries failed to stand up well while being distributed so that after about 24 hours the loss was very heavy, sometimes as high as 80 to 90 per cent. An examination of the intestines of these fish showed that the epithelial cells were very heavily

parasitized by *Octomitus* and there can be no doubt that this was the cause of their death. Why the intracellular stages should become so abundant at certain times is not, as yet, entirely clear but it is believed that it is largely due to the influence of unfavorable conditions to which fish may be subjected. There is evidence that an increase in temperature or deficiency of oxygen are particularly effective in stimulating the development of the parasite. It has been found, for instance, that fish taken from the troughs and held in cans for 24 to 48 hours without aeration of the water showed a marked increase in the number of intracellular stages in the caecal epithelium. Further evidence that such conditions promote the development of the parasite is furnished by the fact that it has been possible to greatly reduce the mortality during distribution by avoiding overcrowding and lowering the temperature to a point considerably below that at which the fish were formerly carried.

Naturally you are all primarily interested in the development of effective measures for the control of the parasite and I am glad to say that I believe the outlook is distinctly encouraging. It is doubtful if *Octomitus* can be eradicated from the hatcheries but there is every reason to believe that much can be done by improving general conditions under which the fish are held so as to increase their hardiness and vigor. It has been our experience that octomiti-asis is likely to occur whenever fingerlings are subjected to unfavorable conditions which tend to lower their vitality, while if the fish are kept in a healthy, vigorous condition there is usually little trouble from the disease.

It is possible that after all *Octomitus* may not be an unmixed evil if it will force us to keep our trout under better environmental conditions and avoid overcrowding. There is no evidence that the parasite injures wild fish or, for that matter, hatchery fish under natural conditions, and apparently it is only under the unnatural environment of the hatchery that *Octomitus* becomes a serious menace. There is, I believe, food for thought in this fact. Are we not, as a matter of fact, overdoing the matter in our modern hatchery practice? It may be that in our zeal to produce the largest number of fish in the smallest possible space we have overshot the mark. Is it not possible that by giving them more room and more natural living conditions we would not only produce stronger, healthier fish but would also find it more economical in the end?

I am sorry that Dr. Moore and I do not seem to agree on this subject. I am beginning to think that we are dealing

with two different organisms, because the results I arrive at are different in many respects from those Dr. Moore has just given.

There is nothing to indicate that the parasite enters the blood, and I must say I have been unable to find any evidence that it does so. Since Dr. Moore reported finding it in the blood I have completely examined the blood of a large number of infected fish and have not been able to find any trace of the parasite. Of course, that does not necessarily mean that it might not occur in the blood under other conditions. I think, though, that the cycle I have referred to would carry it through to a new infection without the necessity of any development in the blood or in any of the organs, with the exception of the intestines.

PRESIDENT EMBODY: These two splendid papers are now open for discussion.

Discussion

DR. EMMELINE MOORE: I want to congratulate Dr. Davis; his splendid paper is going to make the competition all the keener in the study of *Octomitus*. My observations would confirm what he says with regard to the two cycles, by which the numbers are increased. The cycle includes a rapid division into juvenile forms that strike in again, perhaps many times, increasing the numbers of the intracellular stages. As to the cyst that he has particularly referred to, I have not been fortunate in finding that, but as it conforms in general type with that of *Giardia* I do not doubt that he is on the right track there. But I have found lately in the study of the sexual glands that the cyst which I have described on two occasions stains identically with the adult *Octomitus*. I should not expect that if there were two individual organisms. Would you, Dr. Davis?

DR. DAVIS: Well, I have learned not to put too much dependence on staining reaction. I have found so many transitional stages in the development of this amoeba into the cyst that I cannot help but feel that it is a cyst of the amoeba.

DR. EMMELINE MOORE: But it would be peculiar, I think, to find it in the gonadal tissue along with *Octomitus*. As I understand it, you found it in the stomach?

DR. DAVIS: Yes. I have not traced the life history of that amoeba further than these stages. In fact, I have not done very much work on it so far. It is not surprising that Dr. Moore has not found this cyst as described; I did not find it myself until this last spring. They occur, apparently, only at certain seasons of the year. I have found them abundant only in the spring, in March and April. I found a few this summer, but I never would have been able to find them if I had not been familiar with their appearance, they were so scattered and in such small numbers. Only rarely does it form in any considerable numbers.

PRESIDENT EMBODY: You found these cysts in the lumen of the intestine?

DR. DAVIS: Yes.

PRESIDENT EMBODY: What was the one you found in the gall bladder?

DR. DAVIS: That is an undescribed species. It is an entirely different species from this one in the intestines. It is a Flagellate; I think it probably should be put in another genus—*Hexamitus* rather than *Octomitus*. It belongs to the same family, the same series of organisms. Only in one hatchery was it very abundant,—at Manchester, Iowa,—and apparently it does not do any injury to the host.

DR. JAN METZELAAR, (Michigan Conservation Commission): With regard to reducing the number of fry in the troughs, what is the greatest number that Dr. Davis would recommend to be carried at a time?

DR. DAVIS: I have not yet come to the point where I would care to give definite advice. Local conditions have to be taken into consideration. From what I have seen I am positive that overcrowding is one of the conditions which tend to bring on this disease. Of course, parasites are going to be present anyway, but the point I have tried to make is that under certain conditions the fish is subject to unfavorable environment, in which case there is necessarily a weakening of vitality and a lessening of the power of resistance to disease. The result is that the parasites increase much more largely than they would under other conditions, and, of course, injure the fish. I do feel that many of our hatcheries have tried to carry too many fish.

PROFESSOR PRINCE: Did Dr. Davis say that the parasite could not get into the blood?

DR. DAVIS: I do not say it cannot or does not get in. All I say is that I have not found any direct or indirect evidence that it does get into the blood.

PROFESSOR PRINCE: When introduced into the epithelial cells of the intestine, does it cause a slight increase in size?

DR. DAVIS: First comes hypertrophy of the cell, and eventually the cell entirely disintegrates.

PROFESSOR PRINCE: Inflammation would then result?

DR. DAVIS: Yes.

MR. TITCOMB: I think every fish culturist will agree with Dr. Davis that one of the chief causes of all our fish diseases is overcrowding. When asking how many fry you can carry to a trough in a given area you would have to bear in mind, as Dr. Davis says, that it all depends on local conditions. No two hatcheries are alike; every hatchery has its own problems. For instance, you use a flow of two gallons of water per minute in hatchery troughs in one place, three in another, five in another, ten in another, to produce the same results with the same number of fish. That is something for which we cannot give a reason, and we have to work it out. But what I rose particularly for was to ask Dr. Moore whether she believes that the *Octomitus* is actually transmissible through the egg?

DR. MOORE: I thoroughly believe it. I have not all the equipment I need at the headquarters of the Conservation Commission, and I find myself going back to Cornell University, for the purpose of using Dr. Gage's dark field apparatus, which is perhaps the most wonderful equipment of the kind. I have studied the blood a great deal under the dark field illuminator and it seems to me there can be no doubt that the parasite is carried in the blood. Yet I want to keep an open mind on this question. Dr. Davis has done some careful work on the life history, but notwithstanding his life cycle, which I no doubt shall eventually confirm, I still believe from the studies I have made that very minute stages are carried in the blood—a conclusion which the more recent studies of the gonadal tissue would seem to confirm. The histological sections of the young embryo disclosing the presence of infected blood in the region of the kidney, the infestation of the nucleus in the brain cells would indicate that. But, I am not infallible.

MR. TITCOMB: Then I assume we have *Octomitus* with us in all our hatcheries.

DR. MOORE: I think it is very general—don't you agree, Dr. Davis?

DR. DAVIS: Yes, I think so.

DR. MOORE: Have you found any hatchery free from it? None of ours are.

DR. DAVIS: Only one hatchery that we visited was free from it, and that was the Neosho, Missouri, hatchery. I found it there, but it was in fish that had been shipped down from Manchester, Iowa. I did not find it in the fish raised at that hatchery.

DR. MOORE: I have found adult wild trout carrying extremely high infections of *Octomitus* in streams that pass directly from the hatcheries and which receive the waste waters and infectious material.

MR. TITCOMB: In those hatcheries where we have not suffered the effects of the disease, may we assume that the temperature of the water has something to do with it if we have it present with us?

DR. EMMELINE MOORE: I have not made a study of that particular point. Perhaps Dr. Davis will answer that.

DR. DAVIS: Water temperature undoubtedly does have something to do with it, as indicated by the fact that we have been able to cut down our loss by simply lowering the temperatures. My experience has been that the parasite begins to increase rapidly in the spring as the temperature commences to rise in the hatcheries.

MR. TITCOMB: Something about 50?

DR. DAVIS: Yes.

MR. TITCOMB: There is not much trouble below 50?

DR. DAVIS: Well, none of the hatcheries which I have visited for the purpose of investigating the parasite have water below 48 degrees anyway. When I suggested that Dr. Moore and I might have been dealing with two different organisms it was not entirely a joke. I am wondering if in your hatcheries you may not have another organism, in addition to *Octomitus*. I have never seen the whirling symptoms

that Dr. Moore has described; I have not seen that in any of our fish, and we have had some that were pretty well loaded with *Octomitus*.

DR. EMMELINE MOORE: The whirling symptom was very pronounced at the Bath hatchery though much less so in some of the others where I have observed it.

MR. LEACH: Speaking of *Octomitus* from the point of view of the fish culturist, we have had our greatest trouble with it at the White Sulphur West Virginia station. It appears that at the White Sulphur station the water is not as well supplied with oxygen as it is at some of our other hatcheries. The disease appears to be most prevalent there among the rainbow trout. They will take out a shipment of rainbows, brook trout and possibly Loch Leven, and they will find their losses to be practically all in the rainbow trout. We have made some experiments in the placing of these infected fish in the streams. We can carry them for twenty-four hours without trouble, but when we carry them forty-eight hours at a water temperature equal to that in the hatchery, trouble will develop. We meet that condition by reducing the water temperature down to about 42, and we have no trouble in transporting the fish forty-eight or even sixty hours or longer. These fish we have planted in the streams seem to survive and give a good account of themselves; under natural conditions quite a number of them, although heavily infected, will survive and stock the streams—what number we do not know. When the eggs are shipped to other hatcheries—Manchester, for instance, where the water temperature is 50—they do not have any trouble in transporting the fish, though *Octomitus* is prevalent at Manchester. At the White Sulphur station it may be due to deficiency of oxygen in the water.

MR. TITCOMB: What is the temperature at White Sulphur?

MR. LEACH: Forty-six to fifty-two, mostly, in the spring. At Manchester it is fifty.

MR. HAYNES: What is the effect upon the trout after it passes the yearling stage?

DR. DAVIS: As I pointed out in my paper, I do not think the parasite is ordinarily a serious menace to the fish after they reach the yearling stage. At only one place have I found any evidence of serious injury to the yearling fish, that was at Manchester, Iowa. I think the explanation there is rather obvious. The fingerling fish are not infected, but the yearlings are. The explanation I see is that in the other hatcheries the fingerlings that survive are more or less immune from the parasite so that in the second year they do not show any serious effects. At White Sulphur we found very few of the yearling fish affected, while at Manchester last year, all through the summer, the disease was very abundant among the yearling fish.

MR. TITCOMB: Is there a high temperature at Manchester in the summer?

DR. DAVIS: No,—fifty. I am not quite satisfied in my mind what the reason is, but the fingerlings are not infected while the yearling

fish are. Evidently it does not involve any serious mortality among the yearling fish, but it does affect their growth.

MR. HAYFORD: At the beginning of our trouble in 1914 and 1915 we did not know what we were up against—we might as well admit it. Dr. Davis has brought out the matter of overcrowding, and building up resistance. Up to 1920 we had had a good deal of trouble and we changed our refrigerator system. I do not see that this has anything to do with the disease, but it has made a wonderful change in our mortality. Under our present system of refrigeration the meat gets no chance to deteriorate in quality; as fast as it is ground up I insist on its being put back in the refrigerator. Our receptacles are kept absolutely clean and scrubbed out as far as possible. That has greatly increased our growth and reduced our mortality among brook trout fingerlings.

PROFESSOR PRINCE: Does the plasmodium spoken of by Dr. Moore show a very definite nucleus? Does it infect the peripheral protoplasm of the ovum, and does it really penetrate the yolk? Years ago I saw what I temporarily called trophoclasts; they were chiefly in the peripheral protoplasm, but they did digest the yolk. I thought they were normal digestive agents in the egg. It may be that they were the very organisms that Dr. Moore refers to as in the nature of a parasite. Of course there is truth in what Dr. Davis said about the decreasing vitality of the fish resulting from the presence of protozoan parasites. I would like a little more light on that plasmodium stage.

DR. EMMELINE MOORE: The plasmodium does not have a stable nucleus. It appears to be an aggregation of extremely minute organisms which I call the small juveniles. Under the dark field illuminator they appear to be an aggregation of minute motile forms, I have never been able either to stain or to see a nuclear body. As to encroachment on the yolk, it appears not to be a normal thing but decidedly a necrotic condition.

PROFESSOR PRINCE: The ova I refer to were ova with a vitelline circulation, and where that is the case the yolk breaks up readily and is taken into the body of the young developing larva. Where you find, as we have in many cases, no vitelline circulation the disintegration is difficult to understand. There must be such an organism as I have spoken of and which I call trophoclast, an organism which accomplishes the digestion of the yolk. But where there is a rich vitelline circulation, as in Salmonidae, it is easy to see how the yolk can be absorbed.

THE POTENTIAL IMPORTANCE OF ARTESIAN WELLS.

BY DR. JAMES ALEXANDER HENSHALL.

Some Suggestions in Regard to their Use in Replenishment of Depleted Trout Streams, and as a Factor in Purification of Polluted Inland Waters.

In the first place I want to say something about irrigation. Many persons regard irrigation as rather a modern aid in the cultivation of crops, but it has been in use for thousands of years. It was practised in Egypt and India and other oriental countries before the birth of Abraham. It was employed by some aborigines of South America, and in south-west United States by the Aztecs ages ago. No American system of irrigation approaches the stupendous and wonderful achievements in irrigation as in that of the Old World. In Egypt and Asia the water for irrigation was mostly supplied by rivers, though artesian wells were also used.

In the western sections of the United States water for irrigation is supplied by gravity from mountain streams. In the arid deserts of the west irrigation canals have been constructed by the Government; these canals are supplied by rivers. Some are a hundred miles in length, a hundred feet wide and several feet deep. A dam is built just below the intake of a canal, and in some cases the entire volume of the stream is deflected into the canal, leaving the bed of the river below the dam comparatively dry. While these canals are of great importance to agriculture, they mean the extermination of all fish life. In the southwestern states of the lower Mississippi valley water is pumped from streams into ponds and reservoirs for irrigation.

Instead of depleting our streams to furnish water for irrigation of crops at the expense of food- and game-fishes, in other words, to rob Peter to pay Paul, there is a better and more economic way. There is an inexhaustible reservoir of water, which like the "widow's cruse," is always full to overflowing. I allude to the "Waters under the earth." Even in remote ages, although the streams were bank full, the people resorted to this supply, and by means of artesian wells brought the water to the surface for irrigation and other purposes.

Artesian wells are of great antiquity; they were known to the Chinese and Egyptians of remote ages. In Europe, in modern times, many wells were sunk, also, some in the Desert of Sahara. The oldest artesian well in Europe is at Artois, France, which was sunk in the twelfth century; from Artois is derived the word "artesian." In Queensland, Aus-

tralia, are more than 1,500 artesian wells, yielding nearly a billion gallons of water per day. These wells are from 1,000 to 4,000 feet in depth. East of the coast range in Australia are a score of wells, some of them a mile or two deep, which have transformed the country from aridity to fertility. In Europe also are wells a mile in depth.

In the United States are numerous artesian wells of various depths. At St. Louis are wells from 2,000 to 4,000 feet deep. In Chicago and other cities are also artesian wells mostly located at industrial plants. Many of our towns and small cities procure their water supply from artesian wells. Most of the farms in Mississippi and other southern states have one or more such wells. Just outside the city limits of San Antonio, Texas, there are still in use irrigation ponds and ditches constructed by the Spanish Fathers of the Church many years ago. The water thus obtained from wells, springs and streams is still used for irrigation. A health resort connected with a hot water artesian well is still in operation. At Poteet, Texas, there are flowing artesian wells, nearly 1,000 feet in depth, which supply water for ponds, bathing pools and reservoirs for irrigation.

We are, as yet, only in the infancy of irrigation. On this point a recent issue of a reliable periodical has the following statement:

“Less than two per cent of the land of the United States is now irrigated, yet reclamation has reached the stage where future progress can be made only through the construction of extensive storage works, or the use of underground water made available by pumping.”

A half century ago, or to be exact, in 1876, after visiting the Philadelphia Centennial Exposition, I stopped on my way home at Warren, Pa., to visit an old brother angler, and to do some trout fishing in the hills near that city. It happened to be at the time of the great oil furore in that vicinity, and many wells had been sunk, some striking oil, some gas, and one, at least, water, while still others were “dry holes.” While fishing down a fine trout stream I came to a tributary brook smelling strongly of sulphur. I noticed that the stones in the brook were blackened by sulphurous acid gas, showing that the brook had been running for at least a year. Upon further investigation I discovered that a hundred yards away was an iron eight-inch pipe about five feet high, with a short elbow at the top from which spouted a full volume of clear, cold and sparkling sulphur water. In boring for oil this vein had been struck. From the constant flow the little brook had been formed. It was two or three feet deep, fifty feet wide, and following the inequalities of the surface a

pretty, winding stream was the result, with aquatic vegetation already growing along its borders.

As it was about noon I sat in the shade of a giant hemlock and ate my lunch. While smoking my postprandial pipe I pondered and meditated on the flowing well and the little brook. I thought of the possibilities of artesian wells rehabilitating our dwindling trout streams by sinking such wells at the sources of the stream, near the shallow water of the spawning grounds. Already the lumberjack had deforested the pine woods region, causing the drying up of the rivulets near the spawning beds, and the consequent disappearance of the crimson-spotted fontinalis.

When in charge of Tupelo (Miss.) Fisheries Station I had further opportunity of studying the matter. At this station were a dozen artesian wells about 400 feet deep. When first sunk they were flowing wells, but later the city of Tupelo, to increase its water supply, sunk a well 1,000 feet in depth, which had the effect to cause all wells in the neighborhood to drop to ten or twelve feet below the surface, and thereafter the water had to be pumped. I found that by pumping eight hours per day one well, through a four-inch pipe, was enough to maintain a constant overflow at the outlet of a two-acre pond.

In the first issue of the monthly magazine of the Izaak Walton League, in August, 1923, I proposed and advocated the use of artesian wells to increase the flow of depleted streams, and also as a means to mitigate and combat the pollution of inland public waters by increasing their volume, and at the same time by aerating the flow, to augment the amount of oxygen so necessary for the maintenance of fish life. As an instance of value of artesian wells in adding to the volume of a stream may be mentioned the fact that Salado Creek, once a small and intermittent tributary of San Antonio River, in Texas, is now the largest tributary of that river, owing to the sinking of an artesian well on its bank in 1912, for the use of a military post.

In the article just alluded to, I claimed to be the first to propose and advocate the sinking of artesian wells for the purposes just indicated. In lieu of what has been said, and in consideration of my experience with such wells while connected with the Bureau of Fisheries, I can confidently advise and earnestly urge the employment of artesian wells for the purification of polluted streams, and at the same time to furnish additional oxygen for the well being of our food-fishes and game-fishes. As the proposed scheme, as outlined, is entirely new, never having been proposed by any one but myself, so far as I am aware, it may seem somewhat

questionable to some; but the plan is reasonable, feasible, self evident, and in my opinion, does not admit of a doubt.

If the well is a flowing one, nothing more is to be desired, otherwise the water must be pumped by windmill, gasoline, steam or electricity, if an electric current is available. At Tupelo station I substituted electric motors for a leaking steam boiler to the great improvement of the service. The water was pumped from a depth of one hundred feet, and could be operated day or night with but little attention.

Although I am now in my 89th year, I hope to live long enough to see my scheme inaugurated and tried out successfully for the purification and rehabilitation of our inland streams, and possibly a return to something of their former abundance of their finny denizens, and at the same time leave to posterity something of the glory of the great outdoors that we enjoyed in the hey-day of our youth; and we pray that the good work may continue, world without end.

Discussion

JUDGE MILES: I think this Society should go on record in some appropriate way as expressing its appreciation of Dr. Henshall's connection with the Society, and of this contribution to its proceedings, coming, as it does, from a man eighty-nine years of age; and that a copy of the resolution be forwarded to him. I would therefore move that the Chair appoint someone to draft such a resolution.

MR. LEACH: I second the motion.

The motion was carried out and Judge Miles was selected by the Chair to draft an appropriate resolution.

CONSERVATION OF WATER SUPPLY AS AFFECTING FISH LIFE.

BY HONORE MERCIER,

Minister of Lands and Forests, Quebec.

Mr. President, I noticed in the report of the meeting at St. Louis last year a motion approving the construction of barrages for the storage of waters and expressing the view that the conservation of the surplus waters of rivers would result in the formation of artificial lakes which would make splendid reserves for fish and game. I thought it might be of interest to the members of this Association to hear a few words with regard to what is being done in the province of Quebec in the creation of such reservoirs.

About fifteen years ago two new services were created under the Department of Crown Lands to examine into and study the conditions affecting the flow of water in our rivers and to see what could be done to create storage reservoirs for the development of water falls and water power. One of these, the Barrages Branch, is directly under the control of the Minister in charge of Crown Lands, and the other, the Quebec Streams Commission, is a board of three members whose duty it is to study the conditions of our rivers and to make recommendations, to the Minister with regard to the construction of barrages.

The first attempt that was made to create a barrage was on the St. Maurice River. The St. Maurice River, which flows into the St. Lawrence near Three Rivers, is about 450 miles long. This barrage is known as the Gouin barrage, named after the Prime Minister of the province at the time, Sir Lomer Gouin, who was, if not the father of the idea, the one who had most to do with its being carried out. The reservoir created by the construction of this dam, which is located at the head waters of the St. Maurice, stores more water than the famous Assouan dam built in the Nile by the British Government. Its water area is over 500 square miles and its capacity is 160 billion cubic feet. Its cost was about \$2,500,000, quite a number of preliminary works being required in connection with its construction. The contractors were obliged to build about twenty-two miles of railway to carry men and material from the Transcontinental railway up to the site of the dam. They had to develop water power to produce electrical energy to the extent of approximately 1,200 horsepower. This reservoir, which is about 150 miles long, has been in operation for six or seven years and is adequately serving the purpose for which it was created.

Other works are proceeding in different parts of the province. For instance, in the Lake St. John district two reservoirs are under construction, one on Kenogami Lake and the other on the River Metis, down below Quebec on the south shore. A reservoir on the St. Francis River in the eastern townships has been in operation during the last four years, and there are others on Lake Brule, back of Quebec here, and also on the River Ste. Anne. We are contemplating the construction of dams for the creation of storage reservoirs on the north river in the Montreal district—Lake Quareau; another one on Lake Ste. Anne, and in different places dams have been erected for the purposes of storage waters on large lakes such as the Des Quinze in the Temiscamingue district; one at Kipawa Lake, and another at the foot of Lake Temiscamingue. We are also studying other districts in this connection such as the lake district of the Upper Ottawa, towards Grand Lake Victoria and some other lakes.

These storage reservoirs were created for purposes which are undoubtedly outside the activities of your Association. They were designed for power purposes only, with the exception, perhaps, of the storage reservoirs on Lake Temiscamingue and Lake Des Quinze, which were erected by the Federal Government in our province more especially to regulate the flow of the Ottawa River for navigation purposes. But it is certain that the creation of these reservoirs must serve another purpose, as was mentioned in the resolution adopted by the Society last year. The large areas of these artificial lakes extend very far into certain parts of the country, creating marshes where the wild fowl, ducks, geese and so on may find a habitat. As for fishing purposes, on all these waters, with the exception of Lake St. John, we have such fish as pike, sturgeon, white fish, and also a very fine fish, which is a very game one—the maskinonge, and I wonder if in all these reservoirs commercial fishing, for instance, could not be established with great profit. On such lakes as Des Quinze and Lake Expanse, which are affected by the construction of the dam at Lake Des Quinze, commercial fishing is carried on under license, apparently with profitable results. If we could find a way of establishing bass, for instance, in those lakes, we would create another asset, so far as fishing is concerned, that would be of great value.

On Lake St. John another development is proceeding which, although not undertaken by the provincial government, is under the jurisdiction of the Crown Lands Department. Lake St. John has an area of between 450 and 500

square miles. A company has undertaken to produce electrical energy by the development of works at the Grand Discharge and the Little Discharge, at the outlet of the lake. They have now been working for a year in the erection of a dam, which, when completed, will enable the production of approximately a million horsepower. The level of the lake will be raised from about 7 to 20 feet, and its area will thus be increased very considerably. In this lake we have trout, and, in the neighboring waters discharging into the lake, the famous Ouananiche. We confidently anticipate that the regulation of the water of Lake St. John will produce good results from the point of view of fishing. I hope, therefore, that the work which is going on under the supervision of our Department will bring good results not only from the point of view of the main objects for which these reservoirs have been created, but also from the point of view of the conservation and propagation of fish and game in our province.

Discussion

MR. DINSMORE: I have been intensely interested in some developments in our own country with respect to the storage of water for various purposes—stream flow control, irrigation water supply, and so on—and I have been impressed by the fact that in the carrying out of these storage projects, which profoundly affect fish life, the fishing interests have been entirely overlooked in many cases until it is too late to do those things which, if done at the outset, would have been of value. The Androscoggin River, in Maine, is said to be the best controlled river in the world. There are hundreds of miles of storage water—sometimes lakes reservoirized and raised; other times rivers dammed, forming large lakes. The Aziscohas dam comes to my mind—on the Magalloway River, a branch of the Androscoggin. The brook trout in that lake since the creation of the dam have been caught in sizes running up to five or ten pounds. One of the most interesting and remarkable instances of the effect of the creation of these dams came to my attention last summer down in New Mexico, where the damming of the Rio Grande at Elephant Butte has backed up the haughty Rio Grande for forty miles. At the head of the reservoir an enormous bed of mud is deposited each year. As the water is drawn from the dam through syphons from a great depth—the dam is more than 200 feet high—there is created below that dam what is perhaps in effect the greatest spring in existence, the Rio Grande River below the dam becoming a stream of perfectly clear water, with a temperature out there in the heart of the American desert uniformly 50 degrees the year round. When it is being drawn from the dam it is a tremendous flow of water, one in which a boat could scarcely be used with safety. Nobody realized that there had been created there a trout stream rivalling the trout streams of the Rocky

Mountains, hundreds of miles to the north, and carloads of spiny-rayed fish were planted in those waters. But before long they were beginning to catch steelhead trout there, trout which must have dropped down from the Colorado Mountains and grown in this water below the dam. That is another very remarkable illustration of the effect of the preservation of trout streams in the mountains upon the waters below. Another thing which I am watching with tremendous interest is the Hetchy-hetchy project which is soon to supply San Francisco with its water. On the Tuolumne River a great reservoir is being created, of a depth of 200 feet, and directly from this reservoir of trout waters San Francisco is taking, through tunnels and pipes, over a distance of seventy-five miles, pure water for city purposes, and the results must certainly be to create a condition which will give San Francisco trout fishing right at its doors. When reservoirs are to be created in any state, the Fish and Game commissioners of that state should watch very carefully what is being done and see that a proper course is taken for the development of the waters for fishery purposes.

PROFESSOR PRINCE: I would like to congratulate Mr. Mercier on the very able contribution he has made to our proceedings. The great Assouan dam built by the British Government in Egypt has been looked upon as a marvel of accomplishment in the way of the storage of water, and it is not only interesting but startling to know that Quebec has carried on works on such an immense scale. I have every hope that the storage water areas referred to by Mr. Mercier will be of great importance from a fisheries point of view. Some years ago there was a controversy between the fishermen of the state of Minnesota and the fishermen of Ontario, bordering on the Lake of the Woods, with respect to the holding back of the water in the Lake of the Woods. One of the most difficult questions the International Waterways Commission had to consider was the damage which, it was alleged, might be done to the fisheries in the Lake of the Woods by the holding back of the water at a dam at the head of the Winnipeg River. I appeared before the Commission and gave it as my opinion, after an examination of the ground, that instead of damaging the fisheries, the holding back of the water would greatly benefit them; that water would accumulate on low, marshy ground—mosquito swamps—to such a depth that the resulting water area would be of value to the fishes of Lake Winnipeg. I anticipated that whitefish, for example—the beautiful whitefish of the Lake of the Woods—would vastly increase if they were given greater spawning ground, and that the raising of the water and the elimination of these marsh areas, which were only the resort of inferior predacious fish, would in the course of time provide splendid facilities for the propagation of whitefish. Before the sittings ended I heard it stated that the United States fishermen interested had changed their views and were of the opinion that the holding back of the water would be of great benefit to them. I think the hope that commercial fishing may be developed by the creation of great areas of reservoirs is one

which is not a mere vision but is quite likely to be realized. Some of the members present may recall that some years ago I read a paper before the Society on Irrigation Canals in the West, as affording possibilities of developing the fisheries in the western provinces of Canada, such as Alberta and Saskatchewan, where the fisheries are not developed owing to the fact that the waters are very shallow, very warm and often very alkaline. The construction of irrigation dams and the creation of deeper waterways and of reservoirs will, in my opinion, lead in the West to a development of the fisheries which will be of great value to the community.

In regard to the fish that may be cultivated in the lakes referred to by Mr. Mercier, I hope he will give us some encouragement that the Ouananiche may receive attention. Of all the fish that the sportsman may look upon with delight and appreciation, I think the ouananiche occupies first place, and if Mr. Mercier by his efforts can do something to extend the areas in which the Ouananiche flourishes he will confer a great benefit upon sportsmen the world over.

The creation of these dams will do something to equalize and to regulate the flow of waters in the rivers below the reservoirs. Now, that is a very important thing. I myself have seen a very great destruction of valuable fish in the upper Ottawa owing to the irregularity of the flow of water. I have seen vast numbers of fish stranded in shallow ponds along the shore which were drained of water by the lowering of the river; in fact, I and some friends of mine, during a summer holiday, spent part of our time putting a lot of these fish back into the main stream. Perhaps somebody from Ontario will tell us whether these young fish are being netted and put back in such rivers as the Ottawa River. We know how extensively that is done by some of the Fish Commissions in the United States, to the great benefit of the fisheries.

SOME EXPERIMENTS ON THE ADDITION OF VITAMINS TO TROUT FOODS.

BY H. S. DAVIS AND M. C. JAMES,
U. S. Bureau of Fisheries.

During recent years we have heard much of the importance of vitamins and of the dire results which follow when our diet is deficient in these necessary, but little known, substances. Just what part they play in the vital activities of animals and plants is not well understood but we do know that they are necessary to our well-being and that without a sufficient supply of vitamins most serious consequences may result. It has become a truism that vitamins are just as essential parts of our diet as are proteins, carbohydrates and fats and that without them normal development is impossible. While the importance of vitamins was first demonstrated in the case of man later studies have shown that they are also essential to the lower animals and it is doubtful if any animal, or plant for that matter, can long exist without them. How many vitamins there may be we do not know but apparently those most essential for the growth of animals are the so-called fat-soluble "A" and water-soluble "B" and "C" and these three vitamins are the only ones which have been dealt with in our experiments.

Since the discovery of vitamins by Funk only a little over a decade ago marvelous strides have been made in our knowledge of these elusive food factors, but until very recently we had no information as to their importance in the metabolism of lower vertebrates. It was recently found by Drummond* that trout eggs are very rich in vitamin A while several investigators have shown that cod-liver oil is far richer in this vitamin than any other known substance. The fact that fish tissues contain such large quantities of vitamin A is in itself an indication that it must be just as essential to them as to higher animals. However, we had no knowledge of the effect of vitamin deficiency on fishes and in order to supply this want feeding experiments were carried on at the Fairport, Iowa, station for about two months during the summer of 1923. In these experiments young carp from the Mississippi River were confined in troughs supplied with running water and fed diets deficient in one or more vitamins. The results clearly indicate the importance of these accessory food factors in the diet of fishes. In every case there was a high mortality, ranging from 40 to 67 per cent

*Coward, K. H. and Drummond J. C. 1922. "On the significance of vitamin A in the nutrition of fish." *Biochemical Journal*, Vol. 16, p. 631-636.

among the fish fed vitamin deficient diets while there were no deaths among the controls which fed a diet rich in these substances. The most striking results were obtained with the fish fed a ration containing no water-soluble B. After 3 or 4 weeks these fish became very nervous and a number developed convulsions which were especially noticeable whenever the covers were removed from the troughs. During these convulsions the fish would dart rapidly from side to side, twisting and whirling about and striking their heads violently against the sides of the trough. At intervals they would leap some distance from the water until finally, with a last convulsive shudder, the fish would sink quietly to the bottom where they would gradually recover and after a few minutes would swim about in a perfectly normal manner. These convulsions became more and more frequent and more intense from day to day until the fish succumbed to the inevitable. Conclusive proof that they were due to absence of B is shown by the fact that in several instances fish which had developed convulsions and would certainly have died if continued on a vitamin deficient diet were fed considerable quantities of yeast and fully recovered within a few hours.

Fish given diets deficient in fat-soluble A showed no distinctive lesions although the mortality was very heavy. As is well known the absence of A causes a disease of the eyes in rats and other mammals known as xerophthalmia, and its failure to affect the eyes in this case may cause surprise. However, it is generally believed that the xerophthalmia is really due to the fact that the tear glands do not function properly in the absence of A so that the results in this case are, after all, only what we should expect. A deficiency of water-soluble C resulted in high mortality with white spots on the gills caused by the development of necrotic areas.

Similar experiments with young trout failed to yield such conclusive results as in the case of the carp owing to our inability to induce the fish to eat vitamin-free foods in any quantity. The results, however, so far as they go are in full accord with those obtained with carp.

We have, then, direct experimental evidence that vitamins are just as essential to fish as to other animals and that for best results it is necessary to feed trout on a diet rich in these food factors. This at once suggests that possibly many of the difficulties which our hatcheries have experienced with trout may be laid to the door of vitamin deficiency. At the Bureau's hatcheries beef heart and sheep liver form the standard foods and a series of experiments were planned to determine if these have a sufficiently high

vitamin content to satisfy the requirements of the fish. These experiments were started at the Manchester, Iowa, station during the summer of 1923 and have been continued during the present summer at the White Sulphur Springs, W. Va., station. With few exceptions rainbow fingerlings have been used exclusively in these experiments. They were divided into lots of 500 each and kept in troughs under as nearly identical conditions as possible. The fish were fed slowly and in small amounts so that while they secured enough for their requirements no excess food remained in the troughs. An accurate record was kept of the weight of all food fed the various experimental lots and of the frequency of feeding. Every precaution was taken to make the mortality record as complete as possible and in order to check up on their growth the fish were weighed at frequent intervals. In fact no effort has been spared to make the experiments as complete and as scientifically accurate as it is possible to do under ordinary hatchery conditions.

It should be emphasized that while these experiments have been planned on a strictly scientific basis the primary object in view has been to determine the possibility of working out a diet which would be superior to those now in general use at the hatcheries. For this reason no diets have been tested which it would not be practicable to use under ordinary hatchery conditions.

In all our work we have relied on cod-liver oil as a source of vitamin A with most satisfactory results. In our first experiments attempts were made to supply water-soluble B by the addition of middlings, green clover, alfalfa and algae; all of which were found to be unsatisfactory for the simple reason that the fish refused to eat either heart or liver when combined with these substances no matter how enticingly it might be offered them. Fortunately, it was found that they did not in the least object to the addition of yeast to their staple diet and this has been used as a source of B in all our later experiments. The C vitamin was disregarded in our earlier work but in some of our later experiments canned tomatoes and orange juice have been used to supply this vitamin. To avoid any complications due to a deficiency of inorganic compounds in the diet complete salt mixtures were used in our earlier experiments but have since been abandoned in most cases since we have been unable to find any evidence that they are necessary, at least when fish are kept in water having a high mineral content. In most cases the fish had received no food previous to the introduction of vitamin diets.

After the discouraging results of our earlier experiments at Manchester due to the fact that the addition of middlings and "greens" made the food distasteful to trout we were particularly gratified at the success of our later experiments in which yeast was used as a source of B. In these experiments (Figs. 1 and 2) the fish fed either heart or liver to which a small quantity of cod-liver oil and yeast had been added showed a marked superiority over the controls which were given a straight heart or liver diet. In the case of the liver-fed fish there was little difference in the growth of the two lots but there was a marked decrease in the morbidity of the fish supplied with cod-liver oil and yeast. In the heart series the vitamin lot showed a marked superiority over the controls both as regards growth and lower mortality. It is also important to note that a comparison of the heart and liver series shows a distinct superiority for the former in both growth and mortality.

HEART SERIES.

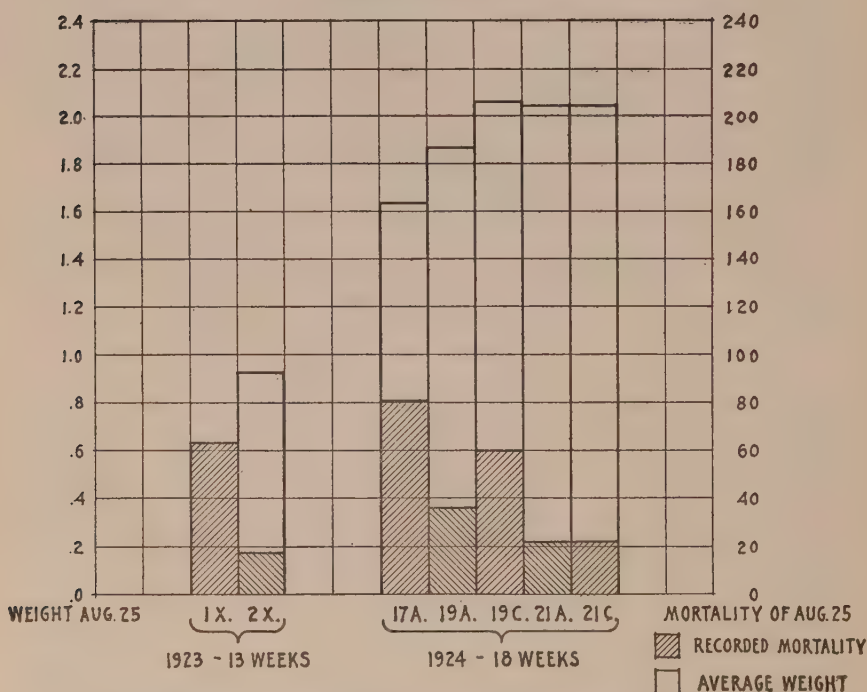


Fig. 1. Diagram showing growth and mortality of rainbow fingerlings fed on beef heart as a basic diet. The figures at the left indicate the average individual weight in grams; those at the right indicate the total mortality. 1X and 2X are from the 1923 experiments, the others are from the 1924 experiments. 1X and 17A fed heart only (controls); 2X and 19C fed heart with the addition of 3 per cent cod-liver oil and 4 per cent yeast. 19A fed heart with 3 per cent cod-liver oil. 21A fed heart with 4 per cent yeast. 21C fed heart with 3 per cent cod-liver oil, 4 per cent yeast and a small quantity of tomato juice.

LIVER SERIES.

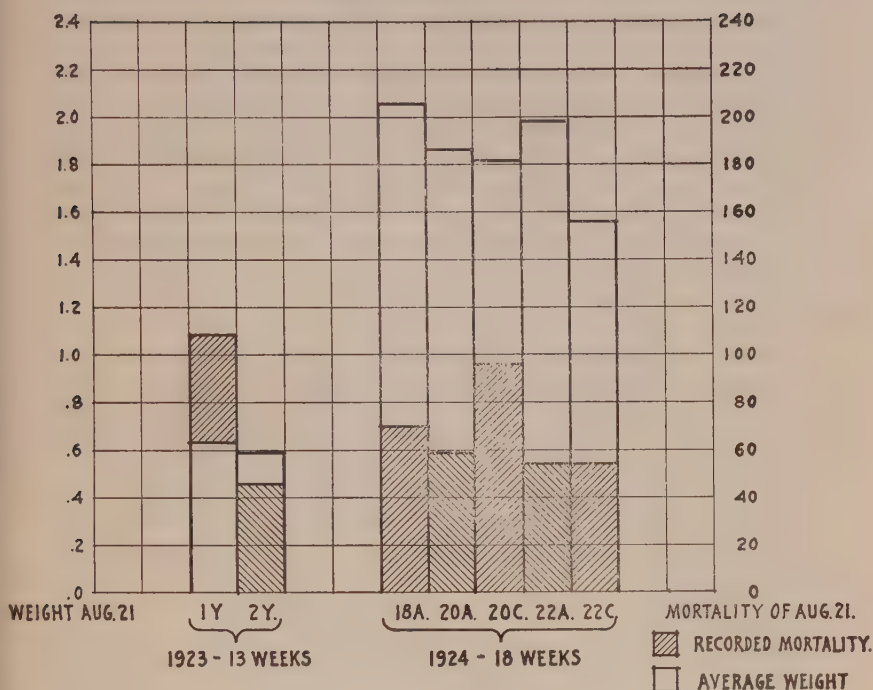


Fig. 2. Diagram showing growth and mortality of rainbow fingerlings fed on sheep liver as a basic diet. The figures at the left indicate the average individual weight in grams; those at the right the total mortality. 1Y and 2Y are from the 1923 experiments, the others are from the 1924 experiments. 1Y and 18A fed liver only (controls). 2Y and 20C fed liver, with the addition of 3 per cent cod-liver oil and 4 per cent yeast. 20A fed liver with 3 per cent cod-liver oil. 22A fed liver with 4 per cent yeast. 22C fed liver with 4 per cent yeast two days per week and pure liver the remainder of the time.

Encouraged by the results of the first season's work it was decided to conduct our experiments during the present season at the White Sulphur Springs, W. Va., station, since it was felt there would be certain advantages in continuing the work at another hatchery where conditions were quite different in several respects from those at Manchester. While the experiments for this season have not yet been included it is believed that a summary of our results up to the latter part of August may not be without interest. The experiments were begun on April 19 last and have been continued to date without interruption. All possible combinations of vitamins A and B are being tried and we are also adding C to the diet in some cases. It will be noted that these experiments have already been conducted for a longer period than at Manchester and the result has been the introduction of some interesting and confusing factors into the situation.

Just as at Manchester the fish in the heart series which were given cod-liver oil and yeast showed an early and unmistakable superiority over the controls in both mortality and growth. In the liver series the growth was at first about the same in all lots and approximately equal to that of the heart controls although, as shown in figures 1 and 2, the mortality in all lots was considerably greater than in the heart series. Later, at about the same stage at which the experiments at Manchester were discontinued, a change in the rate of growth was noted, the liver-fed fish showing an increased growth which threatens to surpass that of the heart series (Fig. 3).

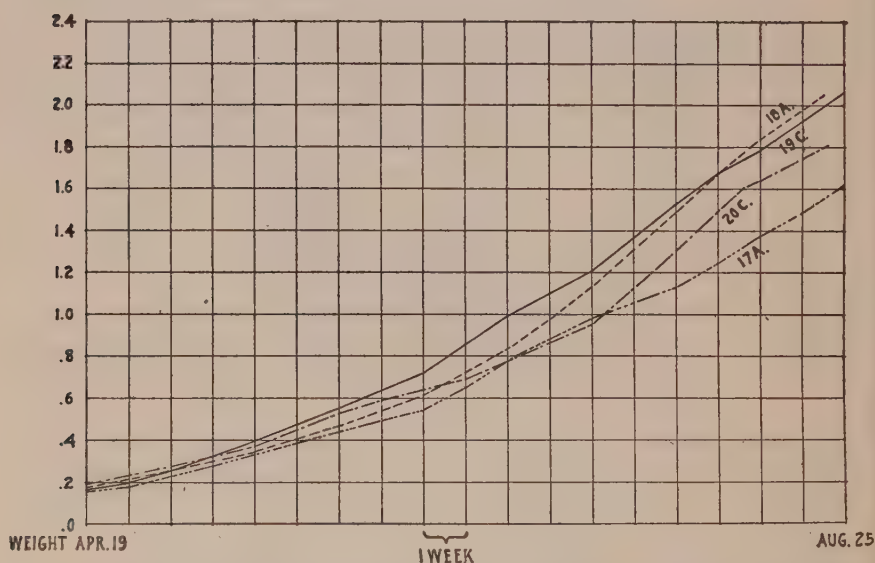


Fig. 3. Curves showing the average individual growth of rainbow fingerlings from April 19 to August 25. Each square represents a period of one week. 17A fed beef heart only (control). 18A fed sheep liver only (control). 19C fed heart with the addition of 3 per cent cod-liver oil and 4 per cent yeast. 20C fed liver with 3 per cent cod-liver oil and 4 per cent yeast.

Until the completion of the experiments any interpretation of these somewhat contradictory results must of necessity be of a tentative nature. However, it is believed that the results already obtained show conclusively that a diet of heart with the addition of cod-liver oil and yeast produces hardier and more vigorous fish than any of the other experimental diets. This conclusion is borne out by some experiments conducted at our request at the Erwin, Tenn., and Wytheville, Va., stations. In these experiments rainbow fingerlings were divided into two lots of 200 fish each. Both lots were kept under as nearly identical conditions as possible and fed the same amount of heart daily; the only difference being that in the case of one lot 3 per cent of

cod-liver oil and 4 per cent of dried yeast was added to the food. At the end of a month it was found that there had been little difference in growth between the two lots but that in the lot given cod-liver oil and yeast there was a greatly decreased mortality. In the Wytheville experiments there was a total mortality of 173 among the controls while in the vitamin lot it was only 80; less than one-half that of the controls. At the Erwin station the experiment was complicated by the fact that there was a heavy loss from "pop-eye" among all the fingerlings but even here the vitamin lot showed a distinct superiority, the mortality being approximately 30 per cent less than that of the controls. It is also significant that in his report the superintendent stated that the fish fed yeast and oil were of much better appearance and color than those given pure beef heart.

It appears that adverse conditions tend to accentuate the superiority of the fish which have received an adequate supply of vitamins. A little thought will show that this is what we should naturally expect, since if environmental conditions are favorable the superior hardiness and vitality of the vitamin lots has little chance to assert itself. But when conditions become unfavorable, when the fish are subjected to influences which tend to undermine their vitality, then it is that the superiority of the vitamin-fed fish becomes most evident. It is also noticeable that the fish given cod-liver oil and yeast are usually more active and exhibit more "pep" than the controls. It may not be a very good recommendation for a vitamin diet but it was found that cannibalism was worst among these fish and that they showed a greater tendency to leap from the troughs on every possible occasion.

Our experiments indicate that the addition of oil and yeast to sheep liver results in little if any benefit although there is a slight decrease in mortality in favor of the vitamin lots. The explanation evidently lies in the fact that liver is comparatively rich in vitamins and contains sufficient amounts of these substances to satisfy the requirements of young trout. This conclusion is supported by the recent experiments of Osborne and Mendel* who found that liver is much richer in vitamin B than was formerly supposed to be the case. The increased growth of the liver-fed fish after about three months may at first appear difficult to explain but there is another factor which must be considered in this connection. All the fish in our experimental lots at White Sulphur were infected with *Octomitus salmonis* while

*Osborne, T. B. and Mendel, L. B. 1923. The effect of diet on the content of vitamine B in the liver. Journ. Biol. Chem. Vol. 58, p. 363-367.

those at Manchester were free from this parasite. When it became evident that the liver-fed fish were growing more rapidly than those fed on heart a microscopical examination was made of the intestines of a number of fish from each series. It was found that there was a very noticeable difference in the abundance of these flagellates in the fish of the two series and that on the average they were considerably more numerous in the heart-fed fish. Unfortunately no fish from either series were examined for *Octomitus* earlier in the season so we are unable to state whether or not there was a similar difference before the liver series began to show an increased growth. It is, however, significant that the increased growth of the latter became evident at about the time the growth-retarding effects of *Octomitus* was most noticeable in the hatchery stock, which would indicate that the flagellates were becoming more abundant.

While the vitamin content of liver appears to be sufficient to satisfy the requirements of young trout it does not by any means follow that it is an equally satisfactory food for adults. The high vitamin content of trout eggs indicates that the vitamin requirements of the fish are probably greater during the period of egg development and it is not impossible that the poor quality of the eggs from hatchery fish may be due, in part at least, to vitamin deficiency. Experiments are now under way which it is hoped will shed much needed light on this important problem.

As to the amount of cod-liver oil and yeast required for best results we are not yet in position to give a final answer. While an excess of these substances would probably do little harm it is obvious that for reasons of economy it is undesirable to use more than is absolutely necessary. In most of our experiments we have used 3 per cent cod-liver oil and 4 per cent yeast but it is probable that this is somewhat in excess of the actual requirements, and experiments are now under way to determine the minimum amounts required for satisfactory results.

During the course of our work several interesting facts have become evident as by-products of the main investigation. A comparison of the heart and liver controls furnishes definite information concerning the relative merits of a straight heart and liver diet. Our experiments indicate that for smaller fingerlings heart gives the best results, both as regards growth and mortality, but that at three or four months liver produces fully as satisfactory if not better growth (Fig. 3). Whether the liver fed fish at this stage are equally hardy is another question. There is evidence

that liver produces fatter, softer fish which are not able to stand up as well under adverse conditions as those fed a pure heart diet.

There has also arisen, as an outgrowth of these investigations, a firm belief that starch in any form has no place in the diet of fingerling trout. We have been unable to find any evidence that trout are able to digest and assimilate starches and the addition of flour or cereal of any kind to the diet of young trout is believed to be unadvisable. We have, as yet, no data bearing on the advisability of the addition of cereals to the food of the adults. It appears probable that the inclusion of these products in the food of brood fish is desirable for the purpose of providing "roughage" but that they appreciably increase the food value of such a diet is open to serious doubt.

Finally we wish to again emphasize the fact that our conclusions to date are necessarily of a more or less tentative nature and that further work may necessitate considerable modifications in some of the views expressed here. Indeed, we consider our work as only just begun since already many inviting fields for future investigation have been disclosed. It is obvious, of course, that by no means all the difficulties which have beset the path of the trout culturist are due to improper feeding and we fully realize that future investigations must include many other factors if we are ever to place trout culture on a firm and substantial basis.

Discussion

MR. RODD: At the end of eighteen weeks how did the total weight of the fish produced compare as between heart and liver?

DR. DAVIS: Our figures are based on the average weight of the individual fish.

MR. ADAMS: Will the higher mortality incidental to the use of liver be offset by the lower mortality among those fed with heart? In other words, you arrive at a certain point and you have a more rapid growth with the liver, but a higher mortality.

DR. DAVIS: The mortality here (referring to chart) I should think, is not appreciably higher. The total mortality for the entire length of the experiment is, because the mortality was higher in the earlier stages; but the mortality at this stage is not appreciably higher in the liver series than it is in the heart series.

MR. ADAMS: Take, for instance, certain regions where it might be necessary to plant fish, say No. 1 fingerlings, as in parts of the West: From this we infer that it would be more satisfactory to feed the heart food in order to accelerate the growth along that stage?

DR. DAVIS: Yes, I think so.

DR. EMMELINE MOORE: When they are so young do they take the heart food as readily?

DR. DAVIS: Yes, we find they do. We have got our best growth in most cases from those fed heart during the early stages. That is true, too, in relation to the controls even, as to those fed the straight heart diet. But later we get a reversal of the conditions.

DR. BELDING: Are you going to put it on a question of time or on a question of weight? According to your chart, up to a weight of one and a quarter grams you would get the best results with your heart combinations, and after that you get the results with your liver. Is it not a question of size or weight rather than a question of age?

DR. DAVIS: I think we put it on age rather than on weight, because I do not think that we are getting the maximum possible weights. We are trying to determine just the amount of food which is eaten, so the food is added to the troughs very slowly and we stop feeding them as soon as they stop eating. Under the ordinary hatchery conditions we would probably get a greater growth than we are getting here. But this method enables us more readily to check up on the food we are giving them, even though the total growth is perhaps not as great. We hope in another season to try some experiment along this line under ordinary hatchery conditions, for the purposes of comparison.

MR. RODD: At what age do you find the heart superior?

DR. DAVIS: Well, about the first eight weeks.

MR. ADAMS: Would it be practicable to utilize the heart food to get that accelerated growth up to that age, and then switch over to liver?

DR. DAVIS: Undoubtedly. In fact, we are rather inclined to think that that may be the advisable thing to do. I do not want to recommend it, however, until we have tried it out.

DR. FIELD: Does Dr. Davis know whether the dried pupae of the silkworm are still available commercially? They were some years ago.

DR. DAVIS: I do not know as to that.

MR. WOODS: Can Dr. Davis indicate, from the investigations so far made, what would be the cheapest and safest bill of fare—the one that would produce the best results?

DR. DAVIS: We believe that the heart with the yeast and possibly a small amount of cod liver oil—not as much as we have been using—would give the best results. We are firmly convinced that the best and hardiest fish we have are those which have been fed on that particular diet.

MR. WOODS: How much would you reduce the cod liver oil from three per cent?

DR. DAVIS: I would not want to say until we have tried it out. We are working on that now. We find that when we reduce the cod liver oil to one and a half per cent the results—so far—are just as good as they were when we were giving the three per cent. The experiments, however, have been running for only about a month.

MR. TITCOMB: In what form is the yeast obtained, and how are the oil and yeast mixed?

DR. DAVIS: The yeast in all cases is dried yeast. Last year in connection with the Manchester experiment we got some ordinary yeast from the Fleischmann Company—yeast commonly used for baking purposes—but this year we have been using dried brewers' yeast, and we think it is more satisfactory. The brewers' yeast costs us about 20 cents a pound, while the Fleischmann people were charging us \$2 a pound for their yeast. We have been getting cod liver oil from the E. L. Patch Company, and we are mixing this with the food. Of course we are using small amounts, but I do not think the ordinary hatchery would find it difficult to mix the cod liver oil and yeast with the food even in large amounts.

MR. TITCOMB: Do you mix it when you grind it?

DR. DAVIS: Yes. If it is thoroughly mixed with the food the fish do not seem to notice its presence at all; they will eat it just as readily as heart or liver.

MR. TITCOMB: I am very glad that you have eliminated the starches. I understood you to say that the trout would not eat middlings when mixed with the food.

DR. DAVIS: We were using rather large amounts of middlings, in order to get enough vitamins.

MR. TITCOMB: Were they cooked?

DR. DAVIS: No, because we were afraid the cooking would destroy the vitamins. We thought that might possibly be a cheaper food, but the fish refused to take the food in any quantity so we had to give that up.

MR. TITCOMB: I suppose you are aware that at the commercial hatcheries the middlings are cooked?

DR. DAVIS: I know that, but we made some investigations as to the ability of the fish to digest starches: we took extracts from the stomach and intestine, added starches, let it stand for a time and then tested it for sugar, but could find no trace of sugar. We also fed starches to the fish, and found that the material passed right through the intestines unchanged, so far as we could see. So that in two ways we checked up on the digestibility of starches in the case of trout. These, however, were experiments on fingerling trout. We are not prepared to say definitely that the larger trout cannot digest starches, although some experiments which Mr. Leach has been carrying on at some of the hatcheries indicate that it is true also of the larger trout.

MR. TITCOMB: I think at the commercial hatcheries they do not begin to use starches until the fish are pretty well advanced. The hatchery troughs you speak of are all standard size—about twelve feet long and fourteen inches wide on the inside.

DR. DAVIS: Yes.

MR. TITCOMB: In figuring the cost of the different diets I suppose you allow for the tremendous waste in the hearts—about 30 per cent?

DR. DAVIS: Well, we have not yet attempted to do very much from that standpoint. In the Bureau's hatcheries the heart is used almost

universally for the young fingerlings, and as I understand it the cost of heart and liver is about the same.

MR. TITCOMB: Heart costs a little less, but the waste makes it more expensive.

DR. DAVIS: I have been told that it would make very little difference from the standpoint of cost which you used. Perhaps Mr. Leach could give us some information on that.

MR. DINSMORE: Heart costs three cents less than liver in northern New England, and we utilize all the hearts by feeding the coarser hearts to the adult fish, so that there is absolutely no waste.

MR. TITCOMB: That is all right where you have large fish. I had in mind more particularly the feeding of the young fish.

MR. LEACH: Answering Mr. Titcomb's question a little further, we find that pressed beef heart, beef liver and sheep's liver are practically the same. The wastage on heart—trimming off the fat and gristle—amounts to about forty per cent, but, on the other hand, there is quite a difference between the food value of the heart and that of the liver. There is more food value in a pound of beef heart than there is in a pound of beef liver. We start our hatches off on beef heart, run that about eight weeks, then usually change to sheep liver. At some of our hatcheries they have a habit of mixing the beef heart or the beef liver up into a soup—almost into a consomme—and scattering it in the trough. I doubt whether the trout really get very much out of such a mixture. In some of our hatcheries they are changing this method of feeding: they grind the beef heart fresh every day; it is not mixed with water. A little bit is taken on the spoon and placed at the head of the trough; another small amount in the center of the trough—they usually place in the trough about what they think the fish will eat up. The young fish take these lumps of food and soon scatter it, because it is ground very fine; and whenever a fish gets a mouthful of that heart it gets something that is of substantial food value. But when the fish swim around through a soupy mixture and get the little fine particles of food that are practically washed out, I doubt whether they get very much value in the way of food. Our western hatcheries have been feeding by this dry method and have obtained very good results from the rainbows and brook trout, the fish being apparently in good condition—much better condition than those at the stations where they have fed the soupy mixture. With regard to the feeding of carbohydrates, we have come to the conclusion at some of our hatcheries that it is a waste of material to feed the so-called shorts. I doubt if there is any food value at all in shorts. At some of our stations we have purchased a burr mill; we are buying our wheat and running it through that mill and grinding it and feeding the whole wheat flour. From experiments we have conducted in feeding whole wheat flour as against shorts we find, first, that the ground wheat is more economical, and, second, we get more value in feeding the ground wheat. To overcome this difficulty regarding starch we are now trying the experiment of letting the wheat sprout

a little before grinding; that breaks down the starch and turns some of it into sugar. I believe we are going to get better results by feeding in that manner and feeding the whole wheat. Of course, that is to the larger fish, not the fingerlings.

MR. TITCOMB: Then you and Dr. Davis are not entirely in accord on this subject of the use of wheat?

MR. LEACH: Dr. Davis has been speaking of fingerling fish; I am speaking of adults. The experiments we conducted at Erwin station last winter seem to prove that there is no value whatever in carbohydrates or flour as food for fingerling fish.

MR. WALCOTT: Is the flour cooked in any way when you feed it?

MR. LEACH: Yes, it is cooked.

MR. TITCOMB: I understood you were feeding the hearts to fry—the first food they got?

MR. LEACH: Yes. We conducted experiments with three lots of fish at Erwin. The first lot were fed ten ounces of beef heart every day. The second lot were fed ten ounces of beef heart with the addition of five ounces of mush, and the third lot were fed six ounces of beef heart and four ounces of mush. The greatest gain was with the first lot, which were fed entirely on beef heart. The second lot, which were fed the same amount of beef heart with the addition of mush, did not show any gain at all. That indicated that there was nothing to be gained by feeding the mush.

MR. MYRON GORDON: Carbohydrates contain some sugar which undoubtedly can be digested by trout, and I do not think it is quite correct to say, therefore, that carbohydrates are entirely indigestible.

MR. LEACH: That is the reason I believe they are of value when fed to older fish, but I doubt if they can be fed to the younger fingerlings.

MR. DAVIS: I agree with you perfectly on that point. If you will recall my statement about starches, I said I did not advise the use of starches—I did not say carbohydrates. I had that point in mind.

MR. HAYFORD: I quite agree with Mr. Leach: I could never see that I got any value from feeding of flours to the small fish. It did seem to me that there was some gain, however, as a result of feeding them to the larger fish.

MR. HAYNES: Do you think it would be safe to feed the fish at the beginning along the lines you are suggesting?

MR. LEACH: At the Springerville, Utah, station they start the fish off with beef heart in the dry stage—that is, without mixing it with water. They put it in the trough and the younger fish soon take the lump and scatter it.

MR. HAYNES: Do you think there is some danger of some of the small fish not getting the food in that event?

MR. LEACH: The mortality at the hatcheries indicates the contrary. When the food is scattered by the fish a great deal of it rolls down the troughs, carried with the current, and the younger fish further down will pick up the small particles. But when you take food that is already

mixed with water and scatter it down the troughs, each particle of food becomes washed and the results are not so good. When you have the food in the form of a soupy mass it is more or less in fibers and the fish have to eat a great deal of the fiber in order to get sufficient food.

MR. HAYNES: I agree with you perfectly in that, as applied to the fish when they attain some size, but I am just in a little doubt whether there is not some danger of the smaller fish failing to get the food.

MR. LEACH: The mortality tables for the Springerville, Utah, station show that the losses under this system have been very light.

MR. HESEN (Iowa): How many fish to the trough?

MR. LEACH: That all depends on the size. In a fourteen foot trough they carry about 10,000 two and a half inch fish. When they first start feeding them they put in 20,000 to 25,000 fish an inch or so in length, and keep on reducing the numbers as the fish grow. When the fish get to three or three and a half inches they reduce the number to about 5,000 fish to the trough, with a water temperature of 50 degrees and a flow of water of about seven gallons to the minute.

MR. MYRON GORDON: I would like to ask Dr. Davis whether he attempted any experiments in feeding the trout on a ration which was absolutely free of any of the vitamins?

DR. DAVIS: Yes, we tried that this season and found we could not get anywhere because the trout took the food in such small quantities that they virtually starved to death.

MR. GORDON: Do you think that if you used a fish meal or animal meal put out by the packing houses, adding to that some lard which is free of vitamins, and probably some cereal, you could get better variations and a more suitable food?

DR. DAVIS: Your fish meal would contain vitamins to some extent. It is not a simple matter to get rid of all the vitamins in any food; it is a long and laborious process of extraction and re-extraction. If you attempt to work it over so many times the trout refuse to have anything to do with it; that has been our difficulty. We can get foods that are deficient, but to get foods that are absolutely free of any one particular vitamin is a very difficult thing.

MR. LEACH: With regard to dried and desiccated foods, the results of our experiments indicate that these are of no value; that the gain made when they are given is very small. When fed beef heart or beef liver there is a slight gain, but the food you pay six cents for is just as effective as some of the products that cost you \$1 or \$1.50 a pound, taking into consideration the gain you secure in the feeding of such foods.

MR. TITCOMB: That includes shrimp meal?

MR. LEACH: All kinds of dried food.

MR. RODD: Our experiments with dried food show the same results; it really produced no growth. The fish sickened very quickly, and there was a question of the food in some instances swelling after it was eaten and causing death. May I ask Dr. Davis whether he included in his

experiments milk of any kind in curdled form, and whether he thinks it would supply the vitamins?

DR. DAVIS: We did try one series of milk foods at Manchester last year. A number of hatcheries had given us glowing reports of the results obtained from the use of milk, so we tried it. Of course we were using a straight milk diet—that is, milk as a basis, just as we used heart or liver, then in some cases adding vitamins to the milk. The results were disappointing. Possibly the use of milk in combination with heart or liver would produce entirely different results.

MR. RODD: You have not tried it in combination?

DR. DAVIS: No. We have that in mind for future experiments.

MR. TITCOMB: You used sour milk?

DR. DAVIS: Yes.

MR. TITCOMB: Mr. Buller has been feeding that for a number of years both to trout and to warm water fishes.

DR. DAVIS: I know that a number of hatcheries have been getting very good results, using it in combination. As I say, that is a point we hope to take up later.

MR. METZELAAR: What is the essential difference between the liver of other fishes and of beef so far as vitamins go?

DR. DAVIS: Judging from the extraordinarily high vitamin content of cod liver oil I should say that cod liver oil would undoubtedly be much higher in vitamin A at least than beef liver.

MR. METZELAAR: It is a quantitative difference.

DR. DAVIS: You know, cod liver oil is very rich in vitamin A—about two hundred times as much as there is in butter, for instance.

MR. METZELAAR: Have you compared it with the fat from beef liver?

DR. DAVIS: A comparison with butter fat would be analagous. Some experiments by English investigators indicate that a high grade of cod liver oil has about two hundred times the amount of vitamin A that butter fat has.

MR. METZELAAR: What I have in mind is that cod liver oil is very expensive and that it would be desirable to replace it if possible.

DR. DAVIS: Well, it is not so expensive, they are using it in the feeding of cattle now. The E. L. Patch people are putting out a standardized cod liver oil for stock food, and you ought to be able to get it at around \$2.50 a gallon or something like that, possibly a little less.

HABITS AND PROPAGATION OF THE SMALL-MOUTHED BLACK BASS.

BY HENRY W. BEEMAN.

The natural habits of the small-mouthed black bass are controlled largely by temperatures. During that portion of the year, in which the water temperature is below 50 degrees, the fish become rather sluggish in their movements, take little if any food and make no growth. The lower temperatures seem to slow up the vital action within the fish bringing about a condition commonly called hibernation. We do not believe the fish actually hibernate, in the full sense and meaning of the word, which, according to Webster is, "to winter, to pass the season of winter, in close quarters, in a torpid or lethargic state, as certain mammals, reptiles and insects." We do not believe the fish become torpid or lethargic and enter into practically an unconscious state. We do not believe the fish resort to sunken hollow logs and crevices, among the rocks and ledges, or in the mud at the bottom of the water they inhabit, as set forth by some writers. The fact that the fish have been found hidden, as above described, when ponds were drawn, is not that they were hibernating, but through fear and fright had resorted to such refuge as hiding places or cover. When we have had occasion to draw any of our ponds, which contained bass, late in the fall or early spring, they would invariably bury themselves in the mud and we have difficulty in recovering them. In the case of fingerlings, it is almost impossible to get all of them. After the ponds were filled we were certain to find some had been left. Whenever our ponds have been drawn in summer, very few bass were found seeking cover. We have confined the adult fish in small shallow ponds here at the hatchery, during the winter months, where they could easily be observed at any time. I always found on approaching the pond, the fish were active enough to swim away with considerable speed, especially if I came suddenly in range of their vision. At no time did they resort to cover, were always to be seen, able to swim about and move rapidly. From these observations together with our experience in taking the fish in the wild state with hook and line, after they had left the shores in fall, I am led to believe they do not actually hibernate during the winter months in the latitude of Connecticut and southern New York, but will be found capable of considerable action. I do believe low temperatures produce a sluggish condition, that the vital action is considerably retarded, and that the

fish live on through this period, consuming very little stored up energy, and with little if any bodily loss. At the hatchery the fish were placed in a small shallow pond with a supply of shiners. Late in March, the following spring on drawing this pond, practically all of the shiners were left untouched and the bass had lost very little if any in condition, so far as I was able to determine by observation only. In taking bass with hook and line, in the wild state, in early spring, through the ice and with those wintered at the hatchery, found them plump, in fine condition generally, having lost very little relative to weight and condition during the winter.

The time when the fish leave their summer haunts and practically cease to feed, varies in different bodies of water, but we believe the temperature is the ruling factor, while the available food supply seems to influence, in a measure, their actions and movements. With an abundance of food the fish would get in prime condition during the summer. When this takes place the fish will not feed readily, naturally gravitate towards their winter quarters and would not appear again in their summer haunts only at rare intervals. If the food supply is scant, the fish are forced to feed later in the season. Some years ago the bass we were intending to winter in the hatchery, had been on rather short rations during the fall, and it was late in November before we secured our annual supply of shiners. When these were liberated in the hatchery, the bass began feeding promptly on them, and judging from their movements, were far from a torpid or lethargic state, the water temperature being around 40 degrees. In the wild state, bass seem to prefer winter quarters on rocky or ledgy bottom in considerable depth. If such places are known, the bass can still be taken with hook and line after they leave their summer feeding grounds, in the fall, and until severe winter weather prevails. I have seldom taken any bass in this manner from late December until early March. With the rising water temperature in early spring, after their winter fast, they are ready to feed and can be again taken in the immediate vicinity of their winter quarters. At this time the fish are rather sluggish in their movements, but as the water temperature rises, they become more active, gradually working into shallow water. About the time the ice disappears, they will be found to have returned to their summer haunts and habits of feeding. They continue feeding until just before spawning takes place, which usually occurs when the water temperature rises to about 64 degrees. The winter habits of the small-mouthed black bass, as outlined

above, apply to the latitude of Connecticut and southern New York. Farther north, this period would naturally be prolonged, while farther south correspondingly shortened. I think in any latitude, a water temperature of about 50 degrees would define the boundary line of their summer activities, and the beginning of their winter inactivities. It may be found, in our northern and colder waters, the fish would remain active in a somewhat lower temperature.

BREEDING HABITS OF THE SMALL-MOUTHED BLACK BASS.

For propagation, strong, vigorous, healthy specimens should be selected. When possible, the males should not be related to the females. We prefer medium sized adults, from one and one-half to three pounds in weight. The males should all be about the same size, as this will have a tendency to prevent fighting for possession of females at spawning time. Larger females will deposit a greater number of eggs, but we believe there is a limit, as regards size and age, beyond which results are not so satisfactory. In all animal life, there is a period in which the reproductive capacity is at its zenith, the subjects are in the meridian of life and then transmit the greatest number of desirable traits to their progeny, and this seems to apply to fishes as well.

The spawning habits of the small-mouthed black bass are controlled by temperatures. A temperature of about 64 degrees seems necessary to ripen the eggs and bring the fish into spawning condition. In late seasons, when the average temperature is below normal, the actual spawning is correspondingly delayed. If this should continue as much as two weeks, the eggs may finally be deposited in a temperature somewhat below 60 degrees.

The sexual excitability of the fish is apparent for a considerable time in advance of actual spawning. In early spring, after the ice disappears, and the water warms sufficiently to bring the fish again into shallow water, in the wild state, we do considerable fishing with hook and line for the purpose of securing breeders, beginning three or four weeks in advance of spawning time. We use a common wash boiler in the boat, for holding the fish, while they are being taken. It quite often happens that when a pair are brought in close contact with each other, in the boiler, notwithstanding only a few minutes have elapsed since they were captured and taken off the hook, will show all the symptoms of sexual excitement, similar to those exhibited immediately before actual spawning, so it is evident, that

the spawning instinct of the fish, and all that goes with that function, is apparent some time in advance of actual spawning. The fish when taken after spawning is over, during the summer and fall, never show symptoms of sexual excitement, such as has been observed at the approach of spawning time.

There is no mating among fish preparatory to the reproductive period. The male alone selects the location and prepares the nest. He instinctively feels the approach of actual spawning time, and a few days in advance of this prepares the nest. In the wild state, the location selected is quite often beside a rock or stump, undoubtedly for protection afforded, and this is usually on the shore side, the depth varying from 2 to 12 feet according to the condition of the water. In very clear water, the greater depths are selected, evidently for overhead protection, for the nest when completed is a conspicuous object. For a number of years we used spawning boxes at the hatchery but they were finally discarded, and gravel of suitable size was placed about the hatchery in convenient depth for securing the fry and is used by the males from year to year.

In preparing the nest the male proceeds to sweep away with fins and tail, all sand and sediment over an area of two or three feet in diameter, according to the size of the fish. A very large male will have a nest fully 4 feet across. When the nest is formed to the satisfaction of the fish, it is a circular, concave, saucer like depression with the sediment, sand and smaller stones, left in a ring around the edge, while the larger stones are left at the center. Stones of size, ranging from 2 to 4 inches in diameter seem necessary, as the eggs, when first deposited are adhesive and attach themselves to these stones, and with this anchorage, are not swept away by the fanning action of the fish, which is kept up more or less constantly, during the hatching period. Only once have I noticed a departure from this habit of nest building among the small-mouths. Once at the hatchery, a male formed a nest among the thick vegetation similar to the large-mouths. These eggs hatched well, demonstrating that the presence of gravel is not absolutely necessary, but preferred as a rule.

After the nest is built, the male seldom leaves its immediate vicinity, and does not go searching for a mate as set forth by some writers. He remains almost constantly on guard, evidently to prevent other ambitious males from appropriating it, watching for the presence of the female. The females when ready to spawn come from the deeper water, one after another, and skirt along the shores search-

ing for a mate. When the female comes within range of the vision of the waiting male, he rushes out to meet her. The pair will remain in close proximity to each other a few moments, but very soon the female will break away, returning to the deeper water, the male following, these movements being executed with apparently the greatest speed of which the fish are capable. The male after following considerable distance seems to become discouraged, gives up the chase, returning leisurely to his nest. I have discovered that the male is wiser than most of us, for in his case, he knows it is not necessary to continue the chase. A little later the female will again approach the nest and when seen by the male, he again rushes out to meet her. This time the pair remain together for a longer period, she accepting for a space of time his attentions, then breaking away again, going back to deep water. This is usually repeated several times, each time the pair remaining together for a longer period, the male gradually working her towards his nest. Finally when the female is ready to actually deposit her eggs, she will have undergone a transformation in color due to a state of sexual excitement. The body color will have paled to a remarkable degree and the dark markings stand out in greater prominence. So marked is this appearance in the female, it has become a sure indication that the fish is just about to deposit her eggs, or has just done so. When a female is in condition to deposit her eggs, the pair settle down over the nest, side by side with vents close together. The actual discharge of eggs seems to be the result of a fluttering convulsivelike movement on part of the female and she turns partially over on her side, discharging a small quantity of eggs, with considerable force, with each movement directly against or just under the vent of the male, he remaining in normal position. Our bass when spawning are very shy and while we have not been able to observe the pair at very close range, we believe that a quantity of milt is discharged by the male simultaneously with the discharge of eggs by the female. The pair as spawning progresses move about over the nest, remain in about the same position, as relates to each other, and spawning goes on until the female has deposited all of the ripe eggs contained in her at the time. When this takes place, the male loses his interest in her, and if she does not show a disposition to leave he will drive her away, and the interest in the future of the progeny, so far as she is concerned, is at an end.

The male now takes entire charge. He almost constantly hovers over the nest, keeping up a fanning motion

of the fins and tail as he moves about directly over the eggs. By instinct, the male seems to know that a gentle circulation of water over the nest and around the eggs is necessary which he creates by the action of the fins and tail as he moves about. This gentle circulation prevents the accumulation of sediment, carries off any foulness arising from dead or decaying eggs and probably aids greatly to the successful development of the embryo. I have, however, demonstrated repeatedly, that the presence of the male is not necessary for the successful development of the eggs. I have many times taken the eggs from the nests immediately after they were deposited, carried them in glass fruit jars, on a table in my home, simply changing the water twice daily and all fertile eggs hatched. The changing of the water seems to have supplied all the oxygen and circulation necessary and under these conditions there would be practically no sediment.

The male hovers almost constantly over the nest. All intruders are immediately driven away. Solicitude and care of the nest, and the future development of the fry is an example of parental care and protection worthy of imitation. If another female in spawning condition approaches his nest he will rush out to meet her, and the pair will execute all the maneuvers as above described. The pair together finally settle down over the nest, and this second female will deposit her eggs right in with those already deposited by the first female, after which she leaves the nest. It sometimes happens that a third female may receive the attention of this male and also deposit her eggs in his nest. The time in which the male appears to show a disposition to spawn with different females is from 30 to 36 hours. After which he will not pay any attention to spawning females. If, during this period, as many as three females have received his attention, and he is a fertile male, nearly all of the eggs will hatch. By actual count 10,868 fry were taken from one such nest. Other nests of the same character have been observed from time to time, at the hatchery, which I have no doubt would have given a greater number, if the fry had been counted. One nest I have in mind, in which the number of eggs deposited was almost beyond belief. This nest was perhaps three feet in diameter, nearly the entire surface was covered with eggs. It is not known how many females deposited their eggs there. This happened when our breeders were on the decline, there being a low state of fertility, and only a small portion of the eggs hatched. This double and triple spawning is influenced largely by a predominate number of fe-

males at spawning time. If the proportion is two or three females to one male, conditions as above described are likely to occur. Our experience in taking the fish in the wild state, for breeders, indicates a scarcity of males. Whether this is due to the fact that early in the Spring the males do not so readily take the bait, I am not sure. It has been our experience, in getting together a lot of breeders, the number of females taken exceeds the males two or three times. If the females are scarce, there is sure to be more or less fighting among the males for possession and we have secured better results when the number of females predominate. A singular instance happened at the hatchery several years ago, which was interesting and unique inasmuch as it is the only one of its kind I have ever observed, resulting in a good hatch. At that time we were using spawning boxes, placed in suitable depth, at intervals of 20 or 30 feet from each other, around the margin of the pond. Two boxes, next to each other, had been appropriated by two males, the larger of which had just spawned with a female. A little later, the second male, the smaller of the two, had secured a female and was giving attention to her. As soon as the first male discovered this he rushed out and attempted to appropriate the female. A battle ensued between the two males, ending in the defeat and driving away of the smaller male. The female readily accepted the attentions of the larger male, he making repeated attempts to get her into his nest. She determined not to go there and the pair finally entered box No. 2 where her eggs were finally deposited. The male now divided his attention between the two nests. Day after day he could be seen going back and forth, fanning the eggs and otherwise caring for their welfare, bringing forth an exceptionally good hatch from both nests. This was made possible since there were no enemies to destroy the eggs, during intervals that one or the other of the nests were left unprotected. When one male undertakes to care for two nests, his attention must necessarily be divided between the two. While caring for one nest, the other is exposed to attacks of nearly all kinds of fishes as nearly all of them will greedily devour eggs whenever opportunity offers. Sooner or later during intervals in which one nest is left unguarded, the egg eaters are sure to find it, and at once commence to devour the eggs. The moment the male returns he will drive away the robbers, but once having had a taste they will again return as soon as the nest is left unprotected and continue their nefarious work. Once begun that nest is surely doomed, as they persist until the last egg is devoured. The same thing is quite likely to happen in the

other nest also, resulting in total failure of both. If the male is a fertile one, and there are no enemies, there is no reason why both nests should not be productive, for the male will faithfully care for both nests as long as any hatchable eggs remain. In the case of one nest only, the male is perfectly able to care for and protect the eggs and young, except possibly in the presence of a school of white perch, which through superior numbers can and do many times completely destroy the eggs. Eels also have the reputation of doing this destructive work.

It sometimes happens a male will spawn with two females, in one nest, at the same time, dividing his attentions between the two until the ripe eggs are deposited. The first instance of this kind was observed at the hatchery. The hatchery is located on my mill property, on the outlet of Lake Waramaug. One day after using the mill and closing down the gate, I heard a disturbance in the wheel pit, as the water was receding. It proved to be a female small-mouth of about three pounds, which had come up the raceway leading from the wheel pit to the main stream. I captured and carried the bass to the hatchery in a landing net, requiring 3 or 4 minutes in which the fish was entirely out of water. At the time bass in the hatchery were right in the midst of their first spawning. This female was released near a spawning box in which a pair were already spawning. The male immediately saw this female and rushed out to her. She at once accepted his attentions and soon after approached the nest with him. In the meantime, the first female remained in the immediate vicinity of the nest, evidently waiting for the return of the male. When he did come with a second female, the first female, after a short interval moved away a little from the nest and the second began to deposit her eggs. After a short interval, the first female returned, and insisted on receiving attention from the male. The second female soon vacated the nest in favor of the first female and the latter proceeded to deposit eggs. This process of alternate spawning continued, the male remaining constantly over the nest and occasionally both females on either side of him would deposit eggs. After all the ripe eggs in both females had been deposited they left the nest. This lot of eggs in due time hatched well. We have from time to time observed this double spawning, two females with one male at the same time, at the hatchery. It is possible this may sometimes happen in the wild state, but we are inclined to the opinion that one of these females ordinarily would look farther for a mate. At the hatchery where the females are always in

excess of the males, they are very persistent in securing the attention of the males, when their eggs are ripe and ready to spawn. The amount of attention from the male required to bring the females into spawning condition depends on the condition of the eggs contained in that particular female. If the eggs are just ripe and the spawning period just at hand, two or three hours may be required before the female will deposit her eggs. On the other hand if the actual spawning of the female has been delayed for any considerable time after her eggs are ripe, she will very soon begin to deposit after coming in contact with the male.

The first spawning of our bass at the hatchery generally extends over a period of about three days, during which all the females containing ripe eggs will have spawned, and if all the males have proved fertile—which is rarely the case—there will be no further deposit of eggs until the first lot have hatched and the fry have been removed. If, however, there are males present who are incapable of fertilizing the eggs, they will not remain with their nests more than two or three days. They seem instinctively to know the eggs will not hatch. They desert and proceed to form other nests in some other location and if there are any females with ripe eggs, there is sure to be another spawning followed by desertion again in another two or three days. Unless these males are removed this will go on through the entire spawning period, which is from 4 to 6 weeks, and the loss from this source is in proportion to the number of males incapable of fertilizing the eggs. If as many as a half dozen of such males are present, where the total number of females may be one hundred, the loss of eggs from this source would amount to fully one-half the product of the season. Every year we encounter more or less of these males, even when taken in the wild state, and if a stock of breeders are held at the hatchery for a number of years, which in the beginning were all fertile, infertility will gradually increase from year to year until finally the stock will be practically worthless as breeders. Several years ago we gave up the attempt to carry our breeders the year around at the hatchery. In fact we were compelled to do this because of the increased difficulty in securing a sufficient number of suitable breeders in the wild state, and their food quantity and variety to satisfy them, when carried in small quarters. In fact, it is impossible to supply them with the variety of food they would get in the wild state and the exercise acquired in securing it, which we believe necessary to keep the fish in vigorous, healthy reproductive condition. About this time a golden opportuni-

ty came to us to test our theory in this respect, through the kindness of a wealthy gentleman (Benjamin R. Kittredge, Carmel, New York) who owns a large estate on which are two beautiful lakes of considerable size, both ideal for black bass. One of these lakes he placed entirely at our disposal. For a number of years we have carried our breeders in this lake, building up all the conditions necessary for the production of healthy, vigorous small-mouthed black bass, and today our breeders there are nearly perfect. We secure our breeders from this lake three or four weeks in advance of spawning time. They are brought to the hatchery and held there until after spawning, after which they are returned to the lake where they pass the balance of the year practically in the wild state. Had not this opportunity come to us at the most opportune time we would have experienced great difficulty in continuing the propagation of the species. The growing scarcity of the small-mouthed black bass in our open waters, due to lack of interest, protection and re-stocking, our failure to secure concession of any kind in procuring breeders other than as prescribed by law in open waters, difficulty in properly feeding them at the hatchery, together with the other difficulties in the propagation of the fish, gave to the future a most uncertain and discouraging outlook.

This work has not received the encouragement and support it should have in the home State, and nearly all the young bass we have produced for a number of years have been shipped out of Connecticut.

This covers practically our observations relative to the spawning habits of small-mouthed black bass. Of late years we pay little attention to the actual spawning of our bass, as we cannot have much—if any—influence over this function and leave them to their own way. We do keep close watch of the nests and eggs after they are deposited.

THE EGGS.

The eggs when first deposited are about the size of a number 6 shot, greyish white in color, adhesive in character and attach themselves to each other and the stones in the nest. The embryonic fish begins to form on the outside of the egg, the egg itself becoming the yolk sac. In the course of three or four days the embryos have developed sufficiently to produce independent motion, when they break loose their attachment to each other and the stones, settling down in the spaces between the stones. At this stage, casual observation reveals nothing. The presence of the male, or

use of the test tube, gives evidence of live and growing fish which are now practically colorless and hidden away in the spaces between the stones. A few days later the developing fish begin to take on color and to work out of the gravel spreading themselves over the nest. In a temperature ranging from 64 to 70 degrees, about 14 days is required for complete development. Then they will have become black in color and begin to rise from the nest. If the temperature should remain as low as 59 to 64 degrees, about 21 days would be required for the full and complete development of the fish. In a temperature of more than 70 degrees the same results are produced in about 7 days.

There are several factors bearing directly on the hatching of the eggs. There must necessarily be a combination of favorable conditions to produce good results. Each spawning period requires three or four days, the first beginning soon after the water temperature rises to about 64 degrees. If for any reason during this period the water temperature should fall to 59 degrees all spawning will cease until it rises sufficiently to start the fish spawning again. If the low temperature continues several days the eggs finally deposited hatch poorly, and likewise that portion of eggs deposited preceding the falling temperature. We have tried to fix the actual degree which would prove fatal to the fertilization and development of the eggs, but evidence secured is somewhat conflicting. We have, however, come to look on a temperature of 59 degrees as unfavorable, and from 60 to 64 as favorable. Eggs deposited in a temperature from 60 to 64 degrees a few hours in advance of a falling temperature seem to fertilize and will survive in a temperature as low as 59 degrees and hatch well. Eggs deposited in a falling temperature are generally a total loss. If a spawning period of the fish is interrupted by falling temperatures and this condition should continue for a number of days before the water warms up sufficiently to favor spawning, the eggs then deposited rarely hatch well. This may be due to the fact that the females, being compelled to carry their eggs after they have ripened, may have become over-ripe and the eggs do not fertilize when finally deposited.

It quite often happens that a fertile male does not fertilize all the eggs deposited and there will be a sprinkling of infertile eggs among the fertile ones. These dead eggs soon change color and fungus growths attack them. This fungus spreads in all directions around the dead egg, enveloping all the live eggs in the immediate vicinity, spreading over a space the size of a silver quarter before it has run

its course. All live eggs attacked by fungus are killed. The loss is directly in proportion to the amount of dead or infertile eggs present. If in considerable numbers, as much as 90 per cent. of the live eggs may be destroyed. This is the result of one condition we find developing among breeders carried a number of years at the hatchery and eventually they become worthless as breeders. This condition we also find to exist in a varying degree from fresh stock secured from the wild state in individual specimens of males. This is one of the factors resulting in our heaviest loss of eggs. In our 22 years experience our greatest difficulty has been in getting enough fry. We expect a yearly average loss of fully one-half the eggs deposited; in fact, if we get 150,000 to 200,000 fry from one-half million eggs we consider it all we can expect. Another factor is low temperatures at spawning time, resulting in very heavy loss. This year has been the most disastrous we have yet encountered. Both air and water temperatures were abnormally low during May and early June. In normal seasons the water temperature in central Connecticut should be around 64 degrees about the 10th of May. Other conditions being favorable, the bass should then spawn and their eggs usually hatch very well. This year the water temperature on June first was 58 degrees and favorable temperature for spawning nearly a week later. The first spawning period being delayed three weeks, was a total failure. The second spawning a week or ten days later was likewise a failure. Spawning continued in an irregular manner until July, not a single egg hatching and we were about to consider the situation a total failure this year. However, there were a few eggs left giving us one more very light spawning. There last eggs hatched perfectly, giving us healthy vigorous fry. We sum up the situation as follows; the first lot of eggs deposited was carried three weeks beyond normal, were over-ripe and would not fertilize. Three days after these eggs were deposited the nests were all deserted by the males. New nests were formed, another spawning took place, eggs in female still over-ripe. Other spawnings continued in quick succession until all the over-ripe eggs had been deposited. Since the males remained with each nest only about three days, and about three days more being required for nest building and spawning, so much time was gained as to bring the last and final spawning about normal. The eggs then deposited, being just ripe, hatched well.

In normal seasons about 14 days are required for the hatching of the eggs. After the fry are removed, the males immediately prepare new nests and another spawning

follows. With females, Nature seems to have provided that about such a period should elapse between the ripening of eggs deposited at different periods. Time varying from 7 to 21 days, according to temperature, for the development of both fry and ripening of eggs. About one-half the eggs contained in the female ripen and are deposited at second spawning, the third and last spawning usually being very light.

THE FRY.

Bass fry do not rise from the nest until the yolk sac is absorbed and they are ready to take food through the mouth. Left to themselves they spread out in a loose swarm and are difficult to capture. When the fry begin to rise our active work begins. When we used spawning boxes we could confine them with screens and take our time in removing them. Since we discarded boxes it is necessary to be right on the job, taking the fry as fast as they rise; otherwise, they soon scatter. This is a very busy time at the hatchery. We are constantly employed going from nest to nest until all the fry are removed. They are placed in large concrete tanks, where they are brought to the advanced fry stage, when they are ready for planting. When the fry first rise from the nest they swim about in an aimless manner with mouth wide open and assume a position at an angle of about 45 degrees. For a time they swim about in this manner, finally assuming a horizontal or natural position. They now begin to take food through the mouth, first feeding on the very small forms of crustacea, and here our work of feeding begins. I have designed and built specially constructed motor boats and equipment for the gathering of the crustacea in sufficient quantities to feed the bass. These boats are operated on Lake Waramaug where their natural food is more or less abundant throughout the season. The crustacea is captured in specially constructed nets which are trailed behind the boats. At intervals the nets are taken in and their contents transferred to a pail of water. From two to four hauls brings in as much crustacea as should be placed in one pail of water. About four such pailfuls fill a 40 quart can. These cans when filled are taken from our crustacea boats by a tender, and their contents placed in the tanks where the fry help themselves. Our rearing tanks are located close by the lake. Our crustacea boats seldom operate more than a quarter of a mile away from the tanks, confining our operations entirely to the central portion of that part of the lake on which the tanks are located and away from the shores. The forms of crustacea most accept-

able to our young bass are found near the surface, and our nets are seldom allowed to sink below a depth of 10 or 12 feet. At greater depths another form of crustacea is obtained that is not so desirable for bass. The varieties most preferred by the bass belong to the genus *Daphne* and *Cyclops*. At times this life is so abundant we experience little difficulty in securing enough to feed our bass. Occasionally these forms drift out of the lake in dense masses. We have a specially constructed frame work across this outlet by the tanks and at such times we capture the crustacea right there. Unfortunately this is not reliable. As the season advances and the demand of our fry is the greatest, the crustacea ceases almost entirely to leave the lake, and we have to depend entirely upon our motor boats for a supply. The erratic habits of the crustacea are also here very noticeable. At times a single haul from one net brings all that ought to be placed in a pail of water; at other times a single haul scarcely reveals any. This might naturally be attributed to an unusual development of crustacea, for a time, and a following diminution might be attributed to the ending of its life cycle. We do not believe such to be the case since the change from one condition to the other often happens in a few hours, and the controlling factor may be due to changes in weather conditions and water temperatures. There may be other causes which we have not yet discovered.

The demands of the fry for food are very great as they feed almost constantly from daylight until dark. During periods of scarcity it is almost impossible to secure food enough to satisfy them. When abundantly supplied they simply gorge themselves. I have no doubt a young healthy bass $\frac{3}{4}$ of an inch in length consumes several hundred crustacea daily, and where the numbers of young bass run into hundreds of thousands, some idea can be formed of the amount of crustacea necessary to satisfy them. When the work of feeding once begins there is no letup; it goes on rain or shine, weekdays and Sundays included, until the fry are ready for planting.

The raising of young bass to the advanced fry stage as we raise them is also an uncertain problem. They are subject to fungus attacks which is fatal. Some seasons the loss from this source is very heavy, coming as it does when the fish are nearly ready for delivery, and it means a heavy financial loss. Three years ago fungus entirely destroyed all of the fry of first and second spawning, while that of the third spawning, reared in the same tanks and under exactly the same conditions, were brought to the advanced fry stage in absolutely perfect condition. Some years the loss may be

confined to one or two tanks containing from 20,000 to 30,000 each. When this fungus appears on a lot of fish their doom is sealed. We have repeatedly tried salt treatment in various ways. While this treatment will check the growth for a time it has never been satisfactory. The fungus appears on the young fish in minute spots. During some seasons it is present on the fry when they rise from the nest and evidently began to appear on them before they were fully developed. The progress of its development becomes apparent in an increased number of white spots which finally prove fatal. The first evidence of the presence of this fungus among our fish is noticed in their efforts to dislodge the spores by brushing against the bottom or sides of the tanks. When the trouble has reached this stage the development is rapid, and in a few days the fish are dead.

We do not know the cause of this trouble or any remedy for it, and are practically helpless even to check its ravages. Dr. Emmeline Moore, in her report of the Biological Survey of Lake George, N. Y., refers to "the susceptibility of the fry to parasitism and to enemy attacks by other minute organisms in the water." We are now inclined to the belief that if minute organisms of a parasitic nature are present at any time during the growth and development of the fry, the injuries inflicted on the fish would present an opportunity for the fungus spores to gain a foothold. Our experience points to the fact that the cause is obscure and may come from this source. If there are present in the plankton, organisms of a parasitic nature at any time during the period we are feeding fry, we are surely gathering them daily and placing them in the tanks, thus helping on the cause that works such fatal results.

The fry are carried in the tanks from 3 to 6 weeks when they have reached the advanced fry stage and are ready to plant. The growth is controlled by temperatures and the amount of food available. Under normal conditions the fry when about three weeks old take on the markings and color of the adult fish and become wily and secretive in their habits; a week later, so marked are these characteristics and so great is their activity that they are ready to plant.

Our methods produce fish fully equal in every respect to those grown in the wild state. They are just as healthy and vigorous, making even more rapid growth under our protection and care. Being absolutely a perfect product, they are abundantly able to take care of themselves when planted. Having reached the advanced fry stage the fish now demand more room, larger forms and greater variety of food. They have developed the wily, secretive habits of the bass to the highest degree and are abundantly able to

to take care of themselves in waters of large area. Nature has now decreed the fish should scatter, each individual going by itself where natural food and good cover are available.

We have made repeated attempts to carry the fish beyond the advanced fry stage to larger sizes before liberating, but unless the number in each tank was reduced to only a few, the result was always fatal. It is not natural for the fish in the wild state to remain in a school after the advanced fry stage is reached, and unless they can follow their natural inclinations as regards food and environment, they cease to take growth, become sickly and unless liberated soon die. If planted along the rock shores in shallow water, where good cover is available, they will take advantage of these hiding places, are safe from their enemies and we believe that the greater part of them survive.

A number of years ago we gave up the attempt to bring the fish up to the fingerling sizes, believing the advanced fry would give our customers better results for money invested. In the early part of this enterprise we made numerous and varied experiments in bringing the fry to fingerling sizes. We produced remarkably fine fish but the cost was so great that the price we would have to ask for them was almost prohibitive and we could not produce them in numbers to meet the demand. The splendid success that followed the planting of advanced fry where conditions were favorable for their growth and development, led us to give up farther attempts to produce fingerlings, and confine our work entirely to the production of advanced fry.

SOME FISH CULTURAL PRACTICES IN THE NEW JERSEY STATE HATCHERY

BY CHARLES O. HAYFORD,

Hackettstown.

Mr. President, Mr. Beeman's paper has covered a good deal of the work we have done in connection with the observation of the adult bass, and so on, so I shall omit any reference to the points which he covered. I hope in this way not only to save time but probably to get all the information desired before the Society.

Let me first make some reference to the bass breeders. When we first started in New Jersey in 1916 we had every known difficulty, I suppose, pertaining to bass culture. To be honest about it, everything failed us for five years. We had one commissioner who fought for bass from start to finish, and that helped us a great deal. We got a number of breeders in the fall, and the first winter the results were unsatisfactory. We built lake No. 4, which contains about three acres, starting from this pond (indicating on plan) and coming across to this other pond in V shape. The approximate length would be 700 feet, with a depth of from seven to nine feet and an approximate width of from 30 to 50 feet. Since we built that pond the loss in wintering bass has probably not been five per cent. The next thing was to make the parent bass spawn when we wanted them to, not when they wanted to. Therefore we came over here (indicating extent of property on map). Our property comprises over 3,000 feet; the fall is 19 feet, and it is about 2,000 feet across. We built a pond down here providing a six inch pipe to carry the water, and arranging for a two foot head on it so that a six inch pipe would carry it. This pond is about 35 feet wide and 250 feet long. It has a temperature of 52, and that temperature does not change. From about the 1st of April to the middle of April we remove the parent bass to another pond, where they remain until about June 1st, when we again remove them and distribute them around among ten other lakes. About ten days after we put them in the breeding ponds they hatch. I will cite two extremes in connection with my first experiences. The first year we took 29 pair of bass and hatched 24; the next year we took 49 and hatched 7. Since that time, however, our average hatch has probably run about 50 per cent; in other words, if we put out 20 pairs of bass we would hatch 10. I had not much difficulty in hatching them or in taking care of the breeders after these five years, but I

did get into a lot of trouble in feeding the little bass. That is where my good friend Dr. Embody comes in. He comes down there, spends sometimes two or three weeks to a lake and works continually on matters affecting insect life and plant life with a view to meeting our conditions.

We draw these ponds off in the fall and let them remain drawn until we get the first heavy frost; then we refill them with water and let them stay full until the latter part of March or perhaps the first of April. Then we sprinkle very fine horse manure all around the ponds and start the flow of water in them. We can draw every drop of water out of any of our 172 ponds, or we can cut out any pond and run the rest of them, with the exception of about five ponds. As the water rises each day the ponds fill slowly and we sprinkle a little more fertilizer around the edge, with the result that about the first of June we have myriads of *Daphnia* in our ponds. Then we start a very slight flow of water and put the big bass in. We do not have very much more difficulty until we reach the stage where the fish are say an inch long; then we work hard to get the *Daphnia*, as mentioned by Mr. Beeman, only we work in absolutely an opposite way. We use concrete ponds to raise *Daphnia* and the large lakes we keep the bass in.

Following the methods outlined in the paper read at the Allentown convention by Dr. Embody, we can raise mosquitoes in those concrete pools in almost any amount we may require. Now, we are going to enlarge that mosquito program. We have discovered two interesting things in regard to producing mosquitoes. At first we used sour milk to the amount of about three quarts to the pond. The creameries bought all the milk this year, so Dr. Embody again rose to the occasion and we switched over to horse manure and clam meal. By employing these processes we get our mosquito larvae by the pail full, so that the question of raising small food for bass seems to be solved. We can use the bone meal fertilizer, which is cheaper, but the clam meal is what we use very largely, following Lydell's practice. Our levels permit us to build ponds anywhere we like; we can either pipe the water in or put it in little ponds and let it seep back in, then start the flow and force the *Daphnia* all out into them.

So much for getting the young bass from three-quarters of an inch to an inch and a half. After a week or ten days we supplement the mosquito larvae with maggots. At first it seems difficult to get the fish to take the maggots but if you persist in it they will take them quite readily. In fact, when the maggot goes to the bottom the bass will stand in

an almost perpendicular position and the minute the maggot begins to squirm the bass will nail him. After a week of that feeding they take the maggots very readily. In order to be sure that we are not dependent on the mosquito larvae and the Scapholeberis and the maggot, we work more or less on the shrimp. We can get any amount of these shrimp from what is the source of our water supply for practically the whole plant. About the 10th of June, as soon as the bass fry starts to feed, thousands of the shrimp are netted and dumped into the ponds to supplement the supply of food that is already there. Then in addition to that we start them on the finely ground sheeps heart. We have some difficulty with that, but by being persistent we find they will soon take that food. Then we also feed them clams, also ground up very small.

Last year we found large numbers of black fly larvae in all of our trout ponds, and Dr. Embury suggested that we put boards in around all these places, in the ponds where the water drops from one to the other, and let the water run out on the boards. Shortly after the water went over the boards they became covered with the black fly larvae; a boy would come along with a piece of flat steel, or almost anything he could get hold of, and scrape the flies off, collecting quantities of them in this way. Dr. Embury also suggested that we use the *Potamogeton crispus* in connection with the feeding of the larvae; the bass will hover around these various groups of *Potamogetons* and you can see them continually pulling off the black fly larvae. The use of these combinations has permitted us to raise either the small or large mouth bass from the fingerling stage, or from one inch up to two to four inches, by the middle of August or the middle of September. The result has been a considerable reduction of our overhead expenses, and the running of things generally on a more satisfactory basis. We have been fishing our plant each year for the last five years in the large ponds, and we have increased our output since 1922 to the extent of fifteen to thirty per cent and have reduced our running expenses sixteen per cent. Here is where a friendly critic in the shape of a commissioner comes in handy with the fish culturist. In 1918, Alexander Phillips, Professor of Zoology in Princeton University, came on our commission. Professor Phillips taught biology in his younger days. He was brought up on a 600 acre farm, was mayor of his city for seven years, and brought to the work the ability not only of a man of science but of a man of business. He demanded an accurate account of the cost of the plant, the amount spent on the grounds, the amount

spent on the farm, the amount required for current repairs, the amount spent in the raising of bass and trout, and so on, with a view to perfecting any weak points that might be disclosed by that examination. Bass seemed to be the weak point; therefore Dr. Embury was called in.

I think most commissioners, taking them as a whole, make the mistake of not requiring their men to be able to use the microscope. Ten years ago I could not use the microscope. Dr. Embury has taken a great deal of pains with me, and now when I look back ten years I wonder that they did not kick me out and be done with it. A great many sportsmen visit our hatchery; they come from the various states, and from what I can learn of their views, as well as from letters from fishermen and from various organizations, there seems to be a tremendous tendency throughout the entire central and southern states to favor the bass. We were very severely criticized in New Jersey up to this year that we had been spending ninety per cent of the sportsmen's money for the propagation of trout and only ten per cent for bass, whereas twenty-five per cent of our stocking waters were trout and seventy-five per cent bass waters. I have received letters from fish culturists in the United States during the last month on this very question. I believe it will be only a short time when we are going to get an entire change in our whole methods of fish culture in a good many ways.

Few states have the opportunity to work the combination that we do in connection with our hatchery operations, but in visiting over forty hatcheries from Maine to Kentucky and as far west as Minnesota I got the impression that in a good many instances small auxiliaries for bass propagation could be established so as to use the waste water as we are doing in the case of a great many of our ponds where we are producing bass. I believe that the average American fish culturist ten years from to-day, possibly less, will have to be able to produce game pond fishes such as small and large mouth bass, pickerel, bluegill, sunfish, and so on. I thank you.

Discussion

MR. BEEMAN: With regard to Mr. Hayford's suggestion as to having the fish spawn when he wanted them to, not when they wanted to, my experience has been that if they cannot spawn when they want to they had better not spawn at all, because it did not amount to anything. But in my ponds the temperature varies; one day the temperature may be near the spawning point and during the night a supply of colder water coming in from the lake will run the temperature down. It may

vary back and forth like that from day to day for quite a considerable period, and that may have the effect of gradually ripening the eggs in the female before permanent temperatures prevail sufficient to bring them to the actual spawning. That may explain why we have had so much loss due to delay of spawning after the females ought to spawn. I would like to hear from Mr. Hayford as to what his experience has been in that respect. I would like to know definitely how the temperatures range in this pond where he holds the fish until he actually wants them to spawn, and how long he would carry them in that pond beyond what would be their natural period in the open waters. That is, I want to get an idea of how much he can delay those fish beyond the ordinary spawning period and get good results.

MR. HAYFORD: Of course we do not have such extreme winters. The temperature of this spring reservoir is 51. We never let this pond get beyond 50. If you let the water get up to 62, 63 or 64 and then transfer the parent bass, you might as well not let them spawn at all.

MR. BEEMAN: In other words, you continue to hold these bass in a low temperature?

MR. HAYFORD: Yes, as long as I can.

MR. BEEMAN: There is no variation in this other pond? That is, when you get into this pond of sixty, the temperature remains permanent?

MR. HAYFORD: Fifty. This pond never changes the year round.

MR. BEEMAN: What is the temperature in the pond where you hold the fish?

MR. HAYFORD: Fifty. Of course, the temperature around the shore or near the edges might go up to 57 or 58.

MR. BEEMAN: After you have held them for a time would there not be a tendency for the eggs to ripen as I have suggested?

MR. HAYFORD: It has been our experience that if we can get to the first of June we can pretty nearly hit 80 per cent on a uniform temperature.

MR. BEEMAN: I conducted an interesting experiment at the hatchery to overcome the variation in temperature in our spawning pond. I have no facilities such as you have; I have to carry the fish in the spawning pond. Our supply of water comes direct from the lake, and as the ponds are located in a very much sheltered position the warm spring weather warms the water up and when the sun disappears the cold water coming in from the lake runs the temperature down. I found after keeping an accurate record of the temperatures three times a day for two or three years that when the water temperature dropped down to about 59 it was at the danger point, and I conceived the idea of trying to hold the temperature in our spawning ponds so that it would not go below the danger point. We had a large 35 horsepower locomotive steam boiler installed of sufficient capacity to heat the water coming in to the extent of ten degrees. If our bass started spawning at 64 and we had a drop in temperature which would destroy the eggs, we started this boiler going, and we found that we could thus hold the

temperature so that it would not vary. The inlet was at the opposite end of the pond from the outlet, so that the water drifted right straight through, and we found we could keep that water above the danger point. For two or three seasons we succeeded in saving the hatch, which would otherwise have been a failure. But it required five or six tons of coal daily and three shifts of men, and at prevailing prices the cost was found to be too great. I finally decided that we would trust to nature and to let the hatch go if the temperatures were falling to the point where it was dangerous. It was too expensive a plant to maintain, but it demonstrated that temperature is the important factor in all this work.

MR. HAYFORD: It is the most important. I may say that at nine o'clock every night during the bass season every bit of water is turned off—and some nights it is turned off at seven if the air temperatures do not look right or the clouds are heavy. By doing this we hold the temperature around the nests at a pretty uniform degree throughout the night. If you let the water run into the ponds you will reduce the temperature five or six degrees in a single night.

MR. BEEMAN: My record of temperatures revealed a very singular situation at the hatchery. I found that in the morning the water temperature would be several degrees lower than it was at night, but as the day advanced the temperature would rise, and I finally discovered that that rise in water temperature was not affected by air temperatures. The air temperature might remain ten degrees below what the water was in the lake, still it would rise during the day. I puzzled over that for a long time, and finally I believe I hit upon the solution. The outlet of Lake Waramaug becomes somewhat shallow, and during the night the temperature there would naturally drop in that shallow water. As the day advanced and the colder water was drawn off from these flats it began to come from further back in the lakes, and when that water further back in the lakes began to be discharged at the outlet the temperature commenced to rise. So that the rising of the water temperature, regardless of the air temperature, was due to the fact that the water was coming from further back in the lake, producing the same effect that you get by drawing water from the bottom of your ponds.

MR. HAYFORD: I have not the records with me, but we took the temperatures at six and seven in the morning, at noon, at six p. m., at nine and ten p. m., over a period of three years, in shallow water, in the intakes and outlets; so that we had the subject pretty well covered. I have no doubt that you have had many experiences along the same line.

MR. BEEMAN: I was impressed with the fact that temperature had a very pronounced influence upon the habits of the small mouth bass, upon the spawning, the hatching of fry and their growth—in fact, upon everything.

MR. HAYFORD: We have found that when the water temperature gets up to 80 or 85 the eyes of the young bass simply bulge out of their heads—I am speaking now about rearing fry. I find that if I go below 70 I begin to lose out on my *Daphnia*; therefore the most desirable

temperature for all concerned would seem to be between 70 and 80.

MR. BEEMAN: I find that the most favorable temperature for rapid growth in all stages.

MR. HAYFORD: We can get spring water as required. We have two ten inch pipes of this pond water coming out from brooks originating in the mountains. We have three ten inch pipes of 52 spring water, one of twelve inches and two of eight. We are so situated that we can throw on the spring water to drop the temperature or the lake water to raise it.

MR. BEEMAN: You undoubtedly have a very remarkable location. There are not many hatcheries where you can so readily and by natural means control the temperature of the water.

MR. HAYFORD: We give Mr. Lydell a great deal of the credit for what success we have there. In fact, very little of it belongs to me, outside of the construction—I will have to take credit for that part of it. I may add that by the running of water from one pond to another you can conserve foods.

MR. LEACH: How do you pair off your fish, male and female—two females to one male?

MR. HAYFORD: We have always been short of females. We may run 75 per cent males, sometimes higher, but that is a fair average.

MR. LEACH: How many females do you put to the acre of water?

MR. HAYFORD: Around twenty or twenty-five males probably, if I had that number to spare, and about thirty females—in that proportion.

MR. LEACH: How soon do you distribute your young fish after they have hatched?

MR. HAYFORD: We do not distribute any of them until they are from two to four inches long.

MR. LEACH: Do you not believe that if under natural conditions the school have been dispersed by the parent fish by the time they have reached the adult fingerling stage, that is just as good a time as any to put them into suitable waters?

MR. HAYFORD: Do you mean when they are three-quarters of an inch to an inch long?

MR. LEACH: Just as soon as possible after they are dispersed by the parent fish.

MR. HAYFORD: There is a lot involved in the answer to that question. I will try to boil it down to our own Jersey conditions. We have an immense number of sunfish, and so on, in all our public lakes. When we first started out and stocked those lakes with advanced fry we did not seem to get very good results, whereas they are beginning to get quite satisfactory bass fishing in a great many of the lakes that we have stocked with fingerlings. It seems to me that the proper course to pursue would be dependent largely on a survey of the waters to determine what other species are in them, what their habits are, and so on. The matter of shore conditions would have a bearing on it, whether weeds or rock, and so on.

MR. LEACH: Under natural conditions they would hatch out and produce results when dispersed by the parent fish, being at that time about three-quarters of an inch in length. If you take these same little fish and put them in suitable natural waters they ought to take care of themselves in the waters in which you plant them as well as they would in the parental waters. That being true I think it is advisable to plant your fish in the spring of the year when they are that size, because they will naturally take care of themselves if they are put in suitable waters. Of course if they are not put in suitable waters you might as well not make the plant at all. If you hold those fish until October and put them out in waters when they are three, four or five inches in length, what are they going to do? You do not know that those waters in which you plant them are still stocked with food. You are taking those fish out of ponds in which there is plenty of natural food, an effort having been made during the summer to furnish them with a continuous supply of natural food, and you are putting them in waters about which there is no certainty as to food, and expecting them to survive.

MR. HAYFORD: I do not think any man who was engaged in fish culture would put the fish in a pond where there was no food. We plant all our own fish.

MR. LEACH: That is where our problem is different.

MR. BEEMAN: With regard to the planting of bass in fry versus fingerling stages, it makes all the difference in the world where the advanced fry are planted. If the weeds are full of sunfish and small pickerel, that is entirely a wrong place to plant them. The bass spawn naturally on the rocky shores, and the fry when they rise from the nest are under the protection of the parent fish until they reach the advanced fry stage. Then they become very active, very wily and secretive in their habits, and of their own accord the school disperses. In planting fry that you have raised at your hatchery these conditions should be imitated; in other words the fry should be planted along the rocky shores away from the weeds, away from the sunfish and pickerel, and where they naturally belong. If that is done I think the work will meet with success.

MR. LEACH: In Kansas, Oklahoma and some of the western states they never hear of rock unless it is used in building.

MR. TITCOMB: Pardon me; you are referring now to the large mouth?

MR. LEACH: I am talking about planting any of these fish. Down at Louisville, Kentucky, where we have a successful small bass hatchery, turning out several hundred thousand small mouth bass annually, we plant them in all sorts of ponds that never had a rock in them—nothing but coarse weeds along the shore. They are mostly planted in ponds and in lakes in which the sportsmen and the public generally are interested in the production of small mouth bass. These fish are put out in the weeds and grass along the edges of the lakes, because under natural conditions the adult fish takes its school into the weeds and into the

grass and disperses it at the proper age. We have had no trouble in getting results down in Kentucky and down through Tennessee, under these conditions. Of course in Tennessee you do have the rocky shores, but, as I have said, we have had no trouble in getting results where we have planted the small mouth bass in artificial ponds where there is no rock.

MR. BEEMAN: In those ponds to which you refer, where there are no rocks or stones, how does the male form its nest?

MR. LEACH: I have seen them build right on the clay bottoms.

MR. BEEMAN: No gravel or anything?

MR. LEACH: No.

MR. BEEMAN: Have you known of an instance where the male makes the nest on the weeds?

MR. LEACH: Sometimes they do, on the roots.

MR. BEEMAN: Evidently the bass is able to accommodate its spawning habits very largely to environment, and possibly the methods we employ in northern waters where there are rocky shores would not apply to other sections. It is true, of course, that among the weeds you find the natural habitat of young pickerel and myriads of other fish which feed on bass in the early stages of their growth. But when the bass reaches the advanced fry stage, if there is any possible chance for him to get under cover he will adopt that cover. He is constantly on the watch for enemies; he is wily and able to take care of himself if there is cover at hand. I may add that he is better able to take care of himself when planted at the fingerling size. I do not think the larger fish feed on the fry, but certainly the smaller fish will feed on the fry up to the advanced fry stage, because they are practically helpless. After they reach the advanced fry stage, however, they have these wily habits and can be reasonably expected to take care of themselves.

MR. LEACH: That is all true, but throughout the Great Lakes region where the small mouth are abundant under natural conditions the small fry have their natural enemies as well as the advanced fingerlings. The fry are preyed upon by the small yellow perch and other small fish. Of course the fingerlings are preyed upon by larger fish, but I do not believe that the adult fish would ever bother the fry. I doubt very much if the adult fish would bother fingerlings, but the yearling fish would.

MR. BEEMAN: There is no question about it. My experience is that the greatest loss of fry is due to yearlings—yearling sunfish, pickerel, perch; nearly all kinds of fish. The fact that the bass have wily and secretive habits strongly developed at that age enables them to survive where others would perish.

DR. KNIGHT: I would like to ask a question of Mr. Hayford. With that marvellous collection of artificial ponds have you ever tried to determine to what extent the so-called enemies of any of the fish that you hatch out would prey upon the fry or fingerlings? I mean you could put them into some of your ponds, could you not, and make practical observations. Have you tried that?

MR. HAYFORD: No. I am not in a position to discuss the figures with any accuracy. We have everything that the Lord created in the shape of fish along in this creek (indicating on map); we get everything from grass pike to large mouth bass, turtles and all the rest of it. But I have never tried to keep a count, because when we draw that lake down we are anxious to get it filled up again. We are going to sub-divide that lake and put a dam up in there so that we can run one section at a time.

DR. KNIGHT: You could do what I suggest, could you not?

MR. HAYFORD: You could, but I do not see that we would really gain anything by testing it out in a small pond like that. We would have to study the conditions of the lakes in New Jersey and the conditions pertaining to the hatchery. From time to time I have had eleven or twelve of the leading fish culturists of the United States visit the hatchery and go over it with me. During the last eight years I have been continuously endeavoring to make the conditions of the hatchery meet the requirements of the state. Our ponds there are of every description, from those with sloping rocky banks as spoken of by Mr. Beeman, to those that have partly rocky shores with streams coming in; almost every lake, with the exception, I think, of two, are characterized by a variety of conditions. I might cite Green pond as an illustration, which is all rocky shore and where the water recedes very quickly. If we do plant any fry at all we put them in there; and we have another lake of the same type. We work the fingerlings more into the lakes that have the larger shallow area. I have a card of every stream in the state, good or bad, and of quite a few of the lakes, but I have not got far enough in the lake proposition to discuss it as to the numbers and the final results. I hope some day to do that.

MR. TITCOMB: This subject of fry and fingerling bass and advanced fry will probably reach the stage which was once reached in a discussion of trout, when the Society devoted days to the question and finally tabooed it in order to devote the time to other subjects. But my experience with the bass has been that, where we have made any surveys under natural conditions they have produced plenty of young and an abundance of fish up to seven or eight inches in length. In the biological survey of Lake George, with which Dr. Moore is quite familiar, we found that there was an abundance of small bass: I could go out and catch twenty or thirty running from seven to nine inches long, with a fly in August. That lake is inhabited by almost everything—lake trout, rock bass, sunfish, and other species—but the little bass of the small mouth species seem to hang around the rocks and take care of themselves. It was very interesting to watch them; they seemed to guard themselves against their enemies. The problem was to get good fishing—fish of a legal size. That is the great problem in all this bass work: in other words, no lake will produce and maintain a fishery for bass in the quantities and numbers that it will maintain many other species. That is particularly true of small mouth bass. Of course there will be a

great difference in the productivity of lakes in that regard, but I have felt that if the bass were protected until they were mature and allowed to spawn naturally we would get somewhere. Unfortunately, in Connecticut we have not yet had an opportunity to try that out, because up to last year it was lawful to take all bass over eight inches in length, and with the intensive fishing carried on in a populous state, surrounded, as it is, by 16,000,000 people who can go in there for half a day's fishing and get back the same day, it was quite a problem. I wanted to ask Mr. Hayford a few questions. First, what is the capital investment in the bass ponds?

MR. HAYFORD: Approximately \$20,000, including all piping, etc. We kept an accurate account from the day I went there in 1912. I have a triplicate of every bill we paid.

MR. TITCOMB: That includes land?

MR. HAYFORD: No, it does not include land. That is for the construction of ponds as far as we have gone.

MR. TITCOMB: That is for both large and small mouth, bluegills and all that?

MR. HAYFORD: Yes. We call it pond culture, which includes both species of bass and bluegills.

MR. TITCOMB: What is the average production annually of small mouth fingerlings?

MR. HAYFORD: The average annual output of fingerlings is about 50,000 in the case of small mouth. We run largely on the large mouth, but I have confined my talk to the small mouth. We can get better success with the small mouth there than we can with the large mouth, under spring water conditions.

MR. TITCOMB: What is your idea of the cost of this annual production of 50,000.

MR. HAYFORD: Well, last year to produce 50,000 small mouth bass fingerlings and 100,000 large mouth bass fingerlings the cost of labor and food was around \$3,300.

MR. TITCOMB: That is pretty good.

MR. HAYFORD: The commercial value would run to about \$8,000, as near as can be judged from the quotations we could get on the different things. That does not include interest on the investment; that is merely labor, with ten percent overhead. It includes management, etc.

MR. TITCOMB: What percentage of fingerlings can you get to the advanced fry stage with small mouth?

MR. HAYFORD: We conducted one test, a very accurate one, in Trout Pond No. 148, which is 50 feet wide and 166 feet long and contains about two feet of water. I put 15,000 fry, as near as we could count them and not hold them too long, into that pond on the 15th of June, 1917, and on the 16th and 17th of September I took out 5,702 fingerling bass from two to four inches long, by actual count. As near as I can get at it from the checks we have made, we run about one fingerling, we will say, to three fry.

MR. TITCOMB: That is, fry right off the beds?

MR. HAYFORD: Yes, just as raised. They were taken from the reservoir and put into this pond as a test. In Pond No. 149 we made a test to see what we could do under a maximum condition. Due to an excrement from the fish that had been there all winter, eight to ten inch trout, the water was brown with *Daphnia*. We put in probably 50,000 five-eighths of an inch fry,—possibly some of them would be three-quarters of an inch—and we shipped out, roughly speaking, around 35,000. I have not the figures with me, but I spent about two weeks on that pond myself to see what we really could do.

MR. TITCOMB: Cannibalism comes after they are an inch to an inch and a half long, does it not?

MR. HAYFORD: Under the method I have spoken of we do not find much difficulty with cannibalism. In this pond, which is a new pond, built this year, containing approximately an acre, we threw in not more than 10,000 fry and about two weeks ago I seined up 6,500 small mouth bass from three to four inches long. They did not vary three-quarters of an inch in the whole pond, but they had every bit of food they could want. The pond was under-stocked compared with the others.

MR. TITCOMB: That is small mouth?

MR. HAYFORD: Yes, I am confining my whole talk to small mouth. In Pond No. 1, one of the first experimental ponds we built, we had five very small pair of small mouth a year ago this spring—five pair out of ten—and we took pretty close to 8,000 fingerlings out of it. Our average production per acre has run from 15,000 to 25,000 of the small mouth and from 20,000 to 50,000 of the large mouth.

MR. TITCOMB: You have only two or three acres devoted to the small mouth?

MR. HAYFORD: Well, we can devote as much as we like to it, but on account of the state being more adapted to large mouth the commissioners very naturally demanded more large mouth. The reason is that many cottagers and their families spend the summer months, July and August, on our New Jersey lakes, most of which are small—we have 250 small lakes—and they are demanding fish like the large mouth bass, bluegill and perch that they can catch during the season. In New Jersey our bass season opens on the 15th of June, and as a rule our small mouth bass, in the lakes that are stocked with them, do not rise to the different lures very much after July 1st until the latter part of September or the middle of October. On the other hand, you can get the large mouth in July and August.

MR. TITCOMB: Have your small mouth in those lakes spawned on the 15th of June?

MR. HAYFORD: A large proportion of the small mouth bass that we netted from the reservoir on the 15th of June this year had not spawned on that date. We had a very backward season in New Jersey, as well as in Connecticut.

MR. TITCOMB: Do you not think that protection during the spawning season is worth more than your fish cultural work?

MR. HAYFORD: I do not know. We have 175,000 sportsmen in the state of New Jersey who are putting up around \$250,000 in license money each year. In other words, they are stockholders to the value of one share each and the Commission is nothing more or less than a board of governors administering these funds. The sportsmen expect the Commission to give them something for their money. We have tried to set the season ahead to the 1st of July, but they would not stand for it. We did get the season set ahead from the 20th of May to the 15th of June so that both seasons would open up alike, but the sportsmen raised up such a howl that the Legislature set it back again to May 20th.

MR. TITCOMB: 50,000 fingerlings, small mouth bass, represents the progeny of how many parent fish in your hatchery?

MR. HAYFORD: On the counts we have made, taking the average, I get about a thousand fingerling bass per pair, in the proportion of about 600 No. 1's, 200 No. 2's and 200 No. 3's and 4's.

MR. TITCOMB: You distribute part of the No. 1's?

MR. HAYFORD: If there is any danger of a food shortage.

MR. TITCOMB: How many waters do these 50,000 go into?

MR. HAYFORD: Well, we do not have any particular amount. Some years ago I rowed around the shores of three lakes, each about three miles in length, to see just how many bass spawned annually; these were municipal reservoirs that were teeming with bass. In one reservoir I found seven nests of bass hatched; in another nine; and in the other five. They all got caught in the cold snap. As you say, proper protection goes a long way, but with lakes as heavily fished as our New Jersey lakes are we find that when we get a poor hatch in a lake the products of our hatchery are necessary to keep it going.

MR. TITCOMB: What is the average number of lakes that you stock in the course of a year with the small mouth black bass?

MR. HAYFORD: Of our 250 lakes we have stocked perhaps a dozen or fifteen.

MR. TITCOMB: 50,000 fingerling divided among twelve or fifteen lakes?

MR. HAYFORD: Yes.

MR. TITCOMB: You get fly fishing immediately after June 15th?

MR. HAYFORD: They do not use the fly so much in New Jersey. The fishermen there use minnows and plugs.

MR. TITCOMB: But you can pick up these males on the nest with a fly?

MR. HAYFORD: I pick them up with a plug. I have got as many as forty of them in the municipal reservoirs from 2 p. m. until dark.

MR. TITCOMB: Mostly males?

MR. HAYFORD: Practically all males.

MR. TITCOMB: I feel that the protection of these nests in public waters is more necessary than the fish cultural work. I do not believe you can keep up with it unless you do protect them.

MR. J. P. SNYDER (Cape Vincent, N. Y.): Last year I presented a paper on the subject of Netting Coarse Fish vs Black Bass. I really wanted some discussion on that paper, but it seems that there was none. At Cape Vincent the question is coming up year after year, is it a good thing to permit netting along the shore of a lake so that coarse fish may be taken in the spring of the year before the bass spawn, prior to June 1st, and again in the fall, after October 1st, after the bass have gone into deep water. Some contend that it is a good thing to take out the surplus bullheads, carp, mullet, pickerel and all that class of fish; others contend it is not. Time and again the fish and game organizations in the state have come to me for my opinion on questions of this kind, and I would like to know the view of the members of this Society on the subject. We have nobody else to go to for information along a line of that kind, and it was for that purpose that I presented the paper last year. We know that just across the St. Lawrence River on the Canadian side, where the netting of coarse fish is permitted the year round, and also in the bays of Lake Ontario, we have better bass fishing than there is on the American side. We have also an illustration in Henderson Bay, where no netting of any kind has been permitted for years and where the bass fishing is poorer to-day than it is in any of those waters where the netting of coarse fish has been permitted. Yet the hook and line fishermen—game fishermen, we might say—and organizations throughout the states, in almost every section, are very much opposed to netting of any kind as applied to the coarse fish along the shore.

Something was said the other day about food for the little bass, and something was said about putting the smelt and other fish in lakes to provide food for adult bass. The question arises whether in providing food for adult bass it is not possible sometimes to destroy the food for the young bass. Again, alewives will come into fresh water and spawn in the spring of the year before the bass spawn; the young alewives begin to feed before the bass fry begin to feed; is it not possible that these young alewives and smelt feed upon the same food that the young bass must later have? Up in Lake Ontario the yellow perch, the pickerel, bullheads, suckers and carp—all that class of fish—go into the shallow waters in the spring of the year, in immense numbers. Is it not possible that the young bullheads, pickerel, yellow perch and other coarse fish are eating the food that the baby bass must later have; that they do this before the bass are even hatched; that they even begin to do it before the bass spawn? I would like the opinion of the meeting on this point.

MR. METZELAAR: Some years ago a plant of smelt was made in Michigan, in Crystal Lake. Primarily intended as a food for salmon, it was a marked success, but the question raised by the last speaker was raised there by various fishermen—whether the smelt was not a serious competitor for the food of the game fish. I took occasion to examine the stomachs of three or four hundred of these smelt, and

I found that almost uniformly the food of the smelt of about six inches and upward in size was a kind of shiner which is almost a pelagic species. This showed that the smelt was a surface feeder; the pelagic shiner was not found in any of the stomachs of the game fishes. Our conclusion, therefore, in regard to the experiment in Crystal Lake was that there was no serious competition. Of course, this applies only to the smelt, not to the alewives.

MR. SNYDER: How about the little smelt half an inch long? Does it feed upon what the baby bass must have? That is the thought in my mind.

PRESIDENT EMBODY: It is possible to confuse two species there. As I understand it, you are speaking about the alewives—you are referring to the true smelt, are you not?

MR. METZELAAR: The Atlantic smelt.

PRESIDENT EMBODY: *Osmerus mordax*?

MR. METZELAAR: Yes.

PRESIDENT EMBODY: And Mr. Snyder is speaking about the false herring.

MR. METZELAAR: I thought he mentioned both.

MR. SNYDER: I mentioned the smelt and the alewife simply because they were mentioned the other day as going into certain lakes and ponds in the spring of the year, and it was suggested that it was a good thing to have the alewives going into those waters because the young alewives provided food for the adult bass. But is it not just possible that the young alewives were eating the food that the baby bass needed?

PRESIDENT EMBODY: I just wanted to be clear as to what you were speaking of and to be sure that we had a correct notion of the two species. One is the false herring and the other is the true smelt. Is there any further discussion with regard to the effects of introducing foreign fish in order to provide food for the native species?

MR. LAIRD: Do the smelt not go to the deep water before the bass begin to feed? When the water cools the smelt usually go to the deeper holes in the lake—that is my experience.

MR. METZELAAR: The smelt will spawn just when the ice melts. In fact, when the ice begins to melt the smelt will run up and spawn in the ice cold water, before any other species does.

PRESIDENT EMBODY: Does the smelt always spawn in a stream?

MR. METZELAAR: Yes, in streams, or close to the mouth of a stream in a lake.

MR. SNYDER: I am thinking of the baby smelt, the little smelt that hatch before the bass even spawn. That little smelt begins to feed before the bass begin to feed. The same is true of your pickerel and of the other coarse fish that I am speaking of—they are all feeding before your little bass begin to feed.

MR. METZELAAR: I should say the danger would be much greater if they hatched contemporaneously.

MR. SNYDER: Is it or is it not a good thing to net such coarse fish as mullet, suckers, yellow perch, pickerel, and so on, from waters inhabited by black bass?

PRESIDENT EMBODY: Now is the time to discuss these questions. The question is, as put by Mr. Snyder, whether it is advisable to permit commercial seining of such fish as suckers, carp and pickerel—some might object to the seining of pickerel and bullheads.

MR. RODD: In Lake Winnipegosis, Manitoba, which was originally a whitefish lake, we have netted during the last two seasons upwards of 700,000 suckers during the spawning period, and we propose to continue that until the population of suckers is brought down more in proportion to that of the whitefish. Of course, that has no bearing on the bass population. In the West we are also destroying in considerable numbers the squawfish in the sockeye waters.

PRESIDENT EMBODY: Squawfish is a large species of minnow which grows in those lakes in Washington and British Columbia sometimes to a pound or two in weight. They are very numerous.

MR. RODD: They are very numerous in some lakes.

PRESIDENT EMBODY: They are about as numerous as suckers are in the East.

MR. RODD: They generally follow the yearling sockeye during migration.

PRESIDENT EMBODY: Would it pay to permit commercial fishing in large lakes where we wish to fish for bass and other sport fish; that is the question for discussion.

MR. DOZE: I might relate a little experience we had out in Kansas at the fish hatchery in connection with a system of 112 brood ponds. Under the old plan, which has been corrected the intake was from a river. The river was dammed and an excellent place was thus afforded for the breeding of gizzard shad. The gizzard shad floated into the upper end of the hatchery in very large numbers. The basses spawned in the upper end of the hatchery were not as large as those in the extreme lower part of the hatchery where the drift of gizzard shad was not very large—indeed, in some places was negligible. With regard to the habits of the gizzard shad, I am somewhat at sea. We consider it a nuisance and throw it away, but wherever we find enormous quantities of gizzard shad we find small bass—that is, small fingerlings compared with those in the ponds where the gizzard shad and the carp and other fishes do not drift. We planted fresh water shrimp in these ponds, and of course we have large numbers of insects which deposit their eggs in the water. But where the gizzard shad are in large numbers the bass do not do as well as where there are no gizzard shad. I would say from our experience in Kansas that the netting of coarse fish, if done before the bass begin to haunt the shores and to make their nests and after the fingerlings have scattered, would be a good thing, and we recommend it in our state. We do not, however, recommend it indiscriminately; the only way we permit it is when a

warden is present; because if you permit the commercial fishermen to take the coarse fish he will take the game fishes along with them. Undoubtedly he is subject to optical illusion.

MR. LECOMPTE: What do you term the gizzard shad? Is it the mud shad?

MR. DOZE: We used to call it the hickory shad. We do not call it the mud shad; they have got a gizzard.

MR. LECOMPTE: We call them both—the hickory or the mud.

MR. DOZE: I would like to ask the fish culturists here if any of them know of a minnow or any other fish that could be planted in the bass ponds to keep the bass from becoming cannibals as soon as their mouth gets large enough to eat. We have to overstock our ponds in order to feed our fish. We find that all the minnows in our state would be no attraction to the large mouth black bass if he can get hold of his own kind, so we undertake to raise enormous quantities of black bass in the ponds in order to feed them to each other.

MR. HESEN: We use the orange spotted sunfish in Iowa.

PRESIDENT EMBODY: What is your experience with goldfish?

MR. DOZE: Our experience is that the bass will not take the goldfish when they can find one a little smaller than he is. We have abandoned the practice introduced by the late Professor Dyche of Kansas.

PRESIDENT EMBODY: I remember that Professor Dyche recommended the addition of goldfish to the ponds, and I always concurred in that.

MR. DOZE: It will not work.

PRESIDENT EMBODY: Possibly your goldfish grow too rapidly out there and thus become larger than the young bass.

MR. DOZE: That is the principal fault. But another fault is that the bass prefers its own kind to any other fish in our waters.

MR. SNYDER: What is the concensus of opinion among the members here on the question that I raised? Is it a good thing to net coarse fish in bass waters, or is it not?

MR. DOZE: I would like to hear from the gentleman from Maryland, who has some bass down there.

MR. LECOMPTE: I am not a fish culturist and would not attempt to put my opinion against that of others who are. We have bass throughout the entire state. There are twenty-three counties, twenty-two of which will not propagate trout; I would say that Garrett county is the only one which has any real trout streams. The majority of our bass streams are fresh water streams coming in from the inlets of Chesapeake Bay. They are very suitable bass streams, being well supplied with vegetation. For instance, in the Transquaking and Chicomacomico Rivers there are places where it is difficult to get through with a canoe owing to the density of the vegetation. In practically every county of the state we have a lot of mill ponds or lakes running anywhere from five to fifty and even one hundred acres in extent. In these ponds you will find a great many of the species of fish to which Mr. Snyder refers as coarse fish, but we do not find that they are

detrimental to the bass. In some of these waters you may catch a bass at one cast and a pike at the next, in the same territory and presumably feeding on the same substances. Up to the last session of the General Assembly it has been lawful to net in those ponds, but at the session of 1924 we enacted a law, to become effective the following June, prohibiting the use of seines and the taking of fish in any manner out of fresh water ponds, which, of course, our lakes are, except by rod, reel and hook. Therefore that eliminates the use of the nets in the ponds. In the rivers, of course, the nets are allowed. In the Transquaking and Chicamacomico Rivers we have plenty of hickory shad; we have carp and numerous other species of fish which you would term as coarse fish; still, in the same waters we catch any number of large mouth black bass. In the western Maryland streams we have considerable numbers of small mouth black bass, but we do not seem to be able to do anything with that species in the eastern counties. I imagine it is owing to the temperature of the water, which is much warmer in the eastern section than it is in the western. But on the whole I do not think the coarse fish in our streams do the bass any harm.

PRESIDENT EMBODY: It is possible that there might be as many fishermen who care to fish for perch and sunfish as there are who want to fish for bass. It seems to me that ought to be considered. Speaking about coarse fish, would it not be well to limit coarse fish in this connection to those forms not ordinarily taken by the line, such as the sucker, for instance? Are there any more contributions to this discussion?

MR. EBEN W. COBB: This question is one in which I have been very much interested in the past. I have always opposed the netting of rough fish during a considerable part of the season, on the ground that it was impossible to limit your net fishermen to locations where there would be no injury to game fish by dragging over the spawning grounds. Moreover, there are seasons of the year when the rough fish bring almost no price, and it is better for the fisherman to confine his fishing to a time of year when he can get his fish to market in good shape. My contention is that injury would be done to the game fish by netting, except in a few cases which would have to be carefully distinguished, during the spawning season.

MR. SNYDER: The seining up there is all done before the bass come into the shallower waters. Nobody has advocated the use of nets during the time the bass are in shallow water; it is before that time, and after.

MR. COBB: I understood the suggestion to be that netting of rough fish be permitted during the entire year.

MR. SNYDER: Oh no.

MR. COBB: That is a different matter.

MR. LECOMPTE: In the two rivers in eastern Maryland to which I have referred, and in others as well—I consider the two mentioned to be our best bass waters—there is no law to prohibit netting at any season of the year. I know of one case in the winter of 1922 where a man took out over a thousand dollars worth of bass from Blackwater

River. The Blackwater and Little Blackwater Rivers are in the same class as the Transquaking and Chicamocomico. These black bass were all taken in one net over a period of three days. It would probably be a very good thing if we could secure legislation in our state to prohibit the netting of coarse fish at that season of the year. When the water becomes warmer, especially after the 15th of March, they very seldom catch any bass in their nets.

MR. ADAMS: It is obvious that there are certain local conditions that have to be met by the man in charge in a particular state. But in view of the difficulty of establishing any fish in our inland waters—ponds of ordinary size—it strikes me as a fair proposition that the commercial seine should be kept out. Where necessary in given localities we could clean up under state direction such coarse fish as may menace the more desirable species. Of course, in what I say with respect to commercial seining I refer to the small ponds of the country, for I am strongly committed to developing the commercial fisheries in any of our inland waters where investigation shows that they are practicable.

PRESIDENT EMBODY: Your suggestion is that the taking of coarse fish be carried out by the state?

MR. ADAMS: As applied to these ponds, control it by the state and keep the commercial fishermen out.

MR. HESEN: May I ask Mr. Hayford how many of the 50,000 small mouth black bass and how many of the 100,000 large mouth black bass produced in New Jersey ponds are put into streams in New Jersey in a year?

MR. HAYFORD: All of our product is distributed right in our own state.

MR. HESEN: The 50,000 produced in the ponds are distributed in streams, lakes or rivers?

MR. HAYFORD: That is not the number hatched; that is the number we plant.

MR. HESEN: Then 50,000 are put in the streams?

MR. HAYFORD: Last year 50,000 small mouth and 100,000 large mouth were put in the streams.

MR. HESEN: At a total cost of about how much?

MR. HAYFORD: Figuring as closely as possible on the basis of the commercial prices, around \$8,000.

MR. HESEN: I wondered whether the 50,000 represented what were hatched or what were actually put in the streams.

MR. HAYFORD: Actually put in the streams.

MR. RODD: I would like to get the experience of the meeting with regard to the planting of eyed eggs. The "Planting of Eyed Salmon and Trout Eggs" was the subject of a paper by Mr. C. W. Harrison, District Inspector of Hatcheries for British Columbia, read at the last meeting of this Society held at St. Louis in 1923. As the method was fully dealt with in that paper, I shall not go into details. The results that were obtained in various tests, in which the eggs were counted

into the planting box and the resultant fry also counted after they were hatched, gave returns as high as from 90 to 96 per cent, and leave no room for doubt as regards the efficiency of the method under favorable conditions, provided the nests are not disturbed by freshets. While care is taken to have the planting done after the freshet season is over, nevertheless there is an element of doubt as to what may happen to the eggs after they are planted, which does not exist when incubation is completed under observation as it is in the hatcheries and the output is distributed as free-swimming fry or in more advanced stages of growth. It is, however, the only method we know of whereby we are able to stock many important but remote spawning grounds to which it is not feasible, with the transportation facilities available, to transfer fry from existing hatcheries. It also facilitates that widespread distribution in those isolated regions that is so essential.

The map which I now show you of the watershed and principal sock-eye spawning grounds of the Fraser and Thompson Rivers gives an idea of our transportation problems as regards fry distribution and the place that egg planting necessarily must take in the stocking of many important spawning grounds until our hatchery service is quite widely extended.

I have also a working model with some blueprints of the planting box that we are using. These I shall pass amongst you; also three photographs showing the box in operation.

It is not an easy matter to properly cover salmon eggs with gravel in a running stream, as those who have tried it can vouch for. With the planting box the eggs are covered with gravel in plain sight on dry land to the depth and in the manner desired.

As I have seen several references in the press during the last year to the question of egg planting, I would like to hear of the experience and learn the views of others in this regard.

MR. LEACH: Several years ago the Bureau of Fisheries undertook to plant the eggs of the Pacific coast salmon in Alaska and also in certain streams of Oregon and Washington in the more or less inaccessible waters. We planted them in waters in which it was a very difficult matter to plant the young fry. These eggs were transported to places above falls and into lakes and streams that it would not be possible for the adult salmon to reach. These lakes and streams were comparatively free from any of the enemies of the salmon. It is our opinion that the young fish when they hatch out will go down over the waterfalls, which in some cases are not very high, possibly a sheer drop of ten or fifteen feet; they will drop into the pools below and be carried on down the streams, eventually reaching the ocean. We believe that the loss on those fish would be very light. Believing that that was a good thing for the Pacific salmon we then thought that it would be well to try it out in the Yellowstone Park and also in the Glacier National Park. But before undertaking to plant them in those parks we conducted experiments at Erwin, Tennessee; Wytheville, Virginia;

and Bozeman, Montana, for the purpose of checking up the results that might be obtained from the planting of eyed eggs. We set aside a few rearing ponds at these different stations. We covered the bottom with gravel and sand, similar to conditions in the stream. We turned a good stream of water into the ponds and we planted in the ponds a certain number of eggs. We raked all the coarse gravel in the ponds up with an iron rake, then we seeded the eggs in with our hands and let them settle down into the gravel, where they were well protected. We found that when the eggs were carefully planted we got good results in most instances. At Wytheville and at Erwin we got about 85 per cent—we did not count the fish until they were swimming up ready to take natural food. At Bozeman we got 92 per cent, so that looked very favorable for the planting of eyed eggs. In Yellowstone Park this summer we planted eyed eggs in several of the more or less inaccessible streams—that is, so far as the planting of trout is concerned. We fenced off a portion of the stream by putting a board into the stream possibly five or six feet from the shore. That board extended four or five inches above the level of the water and formed a pen about twenty feet long. At the upper end it was guarded by the stream, and similarly at the lower end. The eggs were planted under natural stream conditions. We found that in this way we could get a 90 per cent hatch. In some very favorable places we got as much as 95 to 97 per cent, but 90 per cent was the average. These were planted in waters that were not directly in the current of the stream, but in the little eddies and places where they would be protected—about the same place that the fish would spawn in under natural conditions. So I fully believe there is a wide field open to the fish culturist in the stocking of streams with eyed eggs. It is preferable to stock the streams with six or seven inch trout, but there are many instances in which it is better to plant the eyed eggs. I believe it is going to be a success in the future, and that it will be possible to stock a great many streams that have not been well stocked before.

MR. TITCOMB: A commercial hatchery was operated on Long Island for twenty-five or thirty years in which all the eggs were incubated in the gravel in the ditch. Recently that hatchery was closed because of disease; the termination of operations had nothing to do with any failure in connection with the incubation of eggs. I thoroughly believe in this method for the virgin waters. I think it is the only way we can get over the conditions resulting from progress in civilization, as the expression goes—I do not think there is much progress in civilization when it changes the condition of a stream. But it is the only way we can get to the primeval forest and virgin waters; the only way we can come to natural reproduction. I endorse this plan, with the reservation that it is in no way an argument against artificial propagation and the operation of hatcheries. I wish Dr. Knight were here, because I wanted him to hear this—he is the man who hammers the hatcheries. But the hatchery can incubate the eggs to the eyed stage; then the eggs can

be conveniently carried to these inaccessible points—places to which you could not carry fish; and because these waters are still in a natural condition, as God made them, the eggs will be taken care of. So that where the eggs are planted in the gravel in places comparatively free from enemies they cannot but produce the results that have been reported here.

MR. RODD: I understand, though, that both of you prefer the distribution of fry, where possible, the planting of eyed eggs being a good method to adopt to meet an unusual condition.

MR. LEACH: We are speaking of virgin waters which are more or less inaccessible to the planting of fry.

MR. RODD: I may say these are the only waters in which we attempt to do this work.

MR. LEACH: To my mind they are the important waters.

MR. RODD: It enables a much wider distribution than otherwise would be possible.

MR. ADAMS: During the last four or five years we have been conducting a similar experiment in the state of Massachusetts, except that instead of burying the eggs in the gravel we take sections of the same kind of wire screen as is used in the hatching troughs and then have our wardens take the eyed-out eggs, go to the headwaters of certain streams and there rig up on a wire tray substantially the same conditions as obtain in the hatchery troughs. We keep them away from the ground so that there will be a reasonable amount of ventilation and a slight current through the screen; we cover the screen itself over with heavy brush and then thatch with it even shorter stuff so as to effectually conceal the screen. We believe that in our state there is a great field here in the matter of getting the eyed-out eggs into the headwaters of the streams. One of the great difficulties in a great many states in connection with natural propagation is the large number of small obstructions that grow up from year to year on our streams, preventing the trout from getting to the headwaters or into suitable areas to spawn. I agree with Mr. Leach that the time is rapidly approaching when we have got to plan to put out more and more large fish as is done in the state of Pennsylvania.

MR. LEACH: I am glad Mr. Adams brought out that point about using the trays. You will remember that at the Madison meeting we discussed that very same proposition, and Mr. Adams then stated that it was being tried out in his state. As soon as I got back from that meeting and we could get into action, we tried the scheme Mr. Adams has just referred to and we were very successful in hatching out eggs on the trays in the streams. In some places we got hatches of as high as 98 per cent. I used practically the same method that Mr. Adams has described and which he told me about at the Madison meeting. Where it is possible to carry the eggs on trays you can likely get better results than by broadcasting them in the gravel.

MR. TITCOMB: There is one objection to that—I have tried that also. If the trays are located in spring water where there are no sudden changes, you can expect to get results, but if the eggs on the trays are in contact as they are in hatcheries, any invasion of fungus will spread rapidly over the tray. I had one experience where the trays were completely enveloped in fungus and all the eggs were lost. The gravel is an advantage in that it keeps the eggs separate.

MR. RODD: In the method we have adopted the eggs are not broadcast. They are covered on land in the damp gravel and then the whole box is buried and the box removed. The box has a removable bottom.

MR. ADAMS: There is no chance of squeezing or hurting the eggs?

MR. RODD: No. We find it practically impossible to bury the sockeye eggs in the natural spawning ground in a running stream, because they would be carried down. We can cover them as we wish and to the depth we wish by putting them in the box on the bank of the stream adjacent to the spot selected.

MR. ADAMS: One of our fish culturists, Mr. Merrill, after we had started using the wire trays in our state, suggested the use of a wooden box so constructed that it would keep out all kinds of water bugs and other vermin that might be injurious agencies. Only the fact that we were a little short of trout eggs prevented us from putting his suggestion into operation, but I rather think it is the germ of a good idea. Perhaps he will tell us about it.

MR. MERRILL: The idea is not wholly my own. The box Mr. Adams refers to is the Scotch "ridd" or artificial nest—the sides of a box being set in or below a spring where the water will flow through the gravel bottom—used extensively to stock remote streams in the Highlands. It has the advantage of being permanent, and can readily be cleaned out and refilled with gravel each year when the eggs are taken in. It is screened with coarse wire that will keep out any vermin likely to destroy eggs, while letting the fish escape into the stream.

MR. LEACH: We have used a tray with a mesh of about three-sixteenths to three-quarters of an inch. The tray is about fourteen inches wide and from eighteen to twenty inches long. We first rake up a little bed of coarse gravel, then we place the egg tray on the bed and cover it with another tray, each being so arranged that it will be held in place. We put on the tray about 2,000 or 2,500 rainbow eggs. For the salmon work and some other eggs where the fish bury the eggs in a mound we have sometimes used a five gallon coal oil can. We cut out the bottom of the can, which gives us a receptacle about ten inches square. We turn it upside down, put in six inches of gravel, then a layer of eggs and more gravel, a layer of eggs, and so on; we scoop out a little depression in the gravel bed of the stream, turn the can upside down and raise it up, and make the nest in this way.

MR. RODD: We have found the same trouble that Mr. Titcomb has experienced in regard to fungus. If there was anything at all to prevent free circulation, we usually had trouble. Under the methods we have

followed we have secured a hatch of 96 per cent from the fry, by actual count. That, of course, is an exceptional case.

MR. ADAMS: While this is not, perhaps, the most appropriate place to mention it; in view of the fact that I have to leave to-night I want to refer for a moment to this question of brown trout. We have had a great deal of difficulty in getting brown trout to feed, and it occurred to me that in these hatching boxes may be found an effectual method of handling the brown trout egg situation. In connection with some of our hatchery operations it might be possible to plant the eyed-out brown trout eggs in certain of the pools where they would be put in the ordinary course of events, so that they would get more of a start under purely natural conditions than they could in the hatchery. I am not going to start any argument as to the value of the brown trout as against the brook trout, but the more I study the situation the more it seems to me that there is a real field for the production and distribution of the brown trout in the United States; that in some essentials the brown trout is a fish that we have overlooked. We have allowed our prejudice against it to control our judgment in some quarters. The more I discuss this matter with men who have charge of the work in their states the more I see it emphasized that it is more difficult to breed and develop the brown trout than the brook trout. This is merely a suggestion to the fish culturists in the convention, that during the coming year wherever they have the opportunity they look into this brown trout situation closely, in order that at our next annual meeting we may give it some consideration in our program. I refer particularly to the question of getting the fish started and up to say two and two and a half inches in length.

MR. TITCOMB: I have been breeding brown trout for six or eight years. I find that they grow about half as fast as the brook trout. Where brown trout are in the same hatchery with brook trout the fingerlings weigh about half as much as those of brook trout. Where the brook trout run from four to five inches the brown trout run from two and a half to three. But that is characteristic of the brown trout. After the first year they gain on the brook trout and they are the hardest trout of any that I have ever handled. The brown trout are less susceptible to disease than the brook trout. The adult brood fish will withstand disease after a hatchery is totally incapable of maintaining brook trout. In the Catskills the brown trout have been very successfully introduced. In New York state, unfortunately at the beginning they were introduced indiscriminately so that a great many native trout streams have been ruined, but they are a wonderful fish for our larger waters. There are a series of large streams in the Catskills that furnish wonderful fishing to-day, and I have no doubt that suitable waters for them could be found in Massachusetts, New York and Pennsylvania. We are introducing them in a few waters in Connecticut, but with my experience in New York state I am very anxious about it. I do not

see any difficulty in propagating them; the only trouble is that they are a little smaller when distributed as fingerlings than brook trout are.

MR. ADAMS: Do you mean to say that you can take 200,000 brown trout eggs and 200,000 brook trout eggs and get as good results with one as with the other say up to the three inch size?

MR. TITCOMB: There is no greater mortality among the brown trout, but there is slower growth.

MR. ADAMS: That is the only difference to speak of?

MR. TITCOMB: That is the only difference. As to the reason why the brown trout clean out our brook trout in our wild streams, my theory is that after the first year or so the brown trout has such a rapid growth that it becomes larger than the brook trout. The brown trout grow to a weight of ten pounds while the brook trout would be only about two pounds.

MR. ADAMS: So far as the brown trout is concerned, I am interested particularly in getting it from the egg stage up to a fish two or three inches long.

MR. TITCOMB: There should be no trouble at all about raising them.

MR. ADAMS: Do you feed the brown trout any different from the brook trout?

MR. TITCOMB: Not at all.

MR. ADAMS: The procedure is exactly the same in all hatchery methods?

MR. TITCOMB: Absolutely; the same equipment, the same water supply; the same temperatures.

MR. ADAMS: And you find that after the egg sac is consumed and it starts to feed, the brown trout will eat just as readily as the brook trout?

MR. TITCOMB: Yes.

MR. ADAMS: That seems to be the direct opposite of the experience we have had in our state for some time.

MR. TITCOMB: To-day we are distributing brook trout 100 to the ten gallon can—that is all we dare carry. In the case of our brown trout of the same age, hatched under similar conditions, in the same temperature of water, we will carry 200 to the can, so there is that difference in the size. But from that stage on, the brown trout gains on the brook trout.

MR. LEACH: I would not want to get into any argument with the scientists on the subject of the brown trout. I do not think there is very much difference between the Loch Leven and the brown trout—a lot less difference than there is, possibly, between steelhead and rainbow; so I will confine my talk to Loch Leven trout. Last year we collected 8,000,000 Loch Leven eggs in Montana and distributed them to several of our different hatcheries. Our experience is that they grow slowly at first, but we had no trouble in getting them to feed. I think Mr. Adams has had trouble with his trout feeding and he has probably had

a rather poor lot of eggs. If he wants to try out some good eggs I think we could give him a trial.

MR. ADAMS: Would they be brown trout?

MR. LEACH: They would be Loch Leven, which I consider the same as the brown trout. I will challenge you to detect any difference between the Loch Levens and the browns after you get them. You will find the eggs we get from the fish out in Montana far superior to anything you can get in the East.

MR. ADAMS: For the last two or three years we have been buying our eggs from a commercial hatchery in the East. They look good and they hatch almost one hundred per cent, but with us it is a question of getting these fish to feed.

MR. LEACH: Mr. Buller kindly gave us some 50,000 brown trout eggs and we incubated those at the Wytheville, Virginia, station. Our results were similar to yours; we had trouble getting them to feed and we had quite a heavy loss, but the eggs we got in the West were entirely different. I would like to have Mr. Haynes make a statement in regard to the handling of those fish and the feeding of them; he has had experience in that line.

MR. HAYNES: From our experience with the Loch Leven eggs, fry and fingerlings we feel that we would like to raise and produce the Loch Leven in preference to either the brook or the rainbow trout. We had less difficulty in getting them to feed, and less mortality in the eggs, in the fry and in the fingerlings. Our experience has been exactly parallel with that of Mr. Titcomb, and what I would have to say would be almost a repetition of what he has said. The eggs, fry and fingerlings of the Loch Leven are very hardy, and, I repeat, we have had no trouble in getting them to take the food.

MR. ADAMS: Do you feed them just as you would the brook trout fry?

MR. HAYNES: Yes, brook trout fry and rainbow. As Mr. Titcomb has said, you carry just twice as many Loch Leven of the same age to the can as either brook or rainbow.

MR. LECOMPTE: We have not had experience in our state with the brown trout. However, the Isaak Walton League of the city of Frederick have requested the Commission to purchase some brown trout for planting this fall. I would like to know if the fish culturists and the scientists here would deem it profitable to plant brown trout in streams as small as those in which the brook trout flourish. That is, the streams of Frederick county are not very large. I understand that the stream in which they intend to place these 4,000 fingerlings is a larger and more sluggish stream than will support the brook trout. Will the two kinds of trout live in the same stream where the stream is large enough to support them?

MR. WOODS: It seems to me that in the very small streams in Wisconsin the brown trout is being substituted for the brook trout.

MR. TITCOMB: As to the eggs that Mr. Buller sent to us, I can say that we had no trouble with them from the start till the time they were

distributed. Mr. Lecompte may be interested to know that while we choose large streams for the brown trout because they attain a large size, you will find them penetrating the small tributaries and cleaning out the native trout. The only exception I would make to that is the stream which is very heavily wooded and shaded—they will not go into a heavily wooded and shaded brook.

MR. ADAMS: If the brown trout has such a variety of range and grows to be a larger fish, what is the objection to substituting it for the brook trout?

MR. TITCOMB: I will give you another point on the brown trout. When I first went over to New York I found applications on file for brook, brown and rainbow for the same streams, and I was told that I would stir up a very serious agitation, political as well as otherwise, if I tried to differentiate. But I insisted on doing it, and I had the sportsmen with me throughout the state, because of their experience and practical knowledge that many native trout streams had been ruined by the brown trout. I think the state is still carrying out the policy of saving the native streams for the native trout, so far as they have not already been ruined.

MR. ADAMS: When you say "ruined" what do you mean by that?

MR. TITCOMB: I mean that the native brook trout in native brook trout waters in New England cannot be excelled by any other fish, and that is the feeling of sportsmen where the two fish have been introduced.

MR. ADAMS: In what way has the brown trout ruined the brook trout streams? By substituting himself? Is not a twelve inch brown trout as good a sporting proposition for all practical purposes as a twelve inch brook trout? Blindfold a man and feed him the two, can he tell them apart as for edible quality?

MR. TITCOMB: Essentially there may not be much difference between the two fish, but the public sentiment of the sportsmen is for the native trout as between the two. A couple of years ago I received a number of letters and applications insisting upon brown trout for a certain stream in the Catskills which was still a native trout stream. I did not yield to the urgent request for a change to brown trout. I happened to be driving through a portion of the state and as I passed through this little village I called on the man who had been most insistent in the application. He turned out to be the station agent. I asked him why he wanted to put brown trout into this native trout stream, and he said: "I will be frank with you; the reason is that the brook trout are more easily caught. I can catch the brown trout but the native crowd here cannot, and the public will not get them, so that I will get the sport." In other words, he was a dry fly fisherman, and that is the only way to catch the brown trout, except with plug fish in very roily waters. If you get a stream that is well stocked with brown trout, that is one redeeming feature where the stream is fished intensively—you will never get them out when you can fish out the native trout.

MR. ADAMS: Practically all the arguments that have been presented here really favor brown trout as against brook trout in a great portion of our waters.

MR. TITCOMB: Perhaps the attitude of the sportsman is the same in this matter as it is when he prefers grouse to pheasant. There is no doubt that the brown trout has a big place in our country. Most of these streams in the Catskills are brook trout streams naturally. The big streams all are; unfortunately the brown trout clean out the natives in the smaller streams. The man who comes back to his home and wants to catch some of the native trout, perhaps only six to eight or nine inches long, gets instead the brown trout, which is a little bit coarser and not so beautiful; and he does not like it so well. I have no doubt that half the streams of Pennsylvania which were formerly native trout streams are to-day better suited to the brown trout, and that species is filling a big place in that state. We have streams in Connecticut where we occasionally catch brook trout up to two or three pounds, but they are natural brown trout waters, and where we can produce quantities of brown trout in place of a few straggling brook trout we are accomplishing something. I want to see in the stream that species of fish which will produce results, every time, but let us save our native trout streams. They are going fast enough; we are right on the ragged edge here in Quebec. If I talked about Quebec, as I would if we had time, I could tell you a story that would make some of our friends here in Canada take notice, because a lot of the club preserves here are on the ragged edge to-day so far as native brook trout are concerned.

MR. ADAMS: Suppose at the opening of the season the ordinary fisherman is fishing in a trout stream with worms; will the brown trout bite readily to a worm on a hook, as the brook trout will under such circumstances?

MR. TITCOMB: No, he will not.

MR. HAYFORD: In New Jersey we encountered difficulties with the Loch Leven at the small stage, as Mr. Adams did. We got the eggs from Mr. Buller, and we got brown trout eggs from Hudson, Wisconsin, and the result was the same. We exchanged with the California Commission—brook trout eggs for Loch Leven—and I also had brown trout eggs from my own breeders. I observed a difference between the brown trout and the Loch Leven in this respect. The brown trout fry would crowd more or less into the corners and hang to the bottom, while the Loch Leven fry would rise to the top and take the food just as readily as the brook fry did. About five years ago I crossed the Loch Leven with the brown trout with very satisfactory results. There is practically no difference in growth as between the cross and our Loch Leven at the present time, nor is there any difference, so far as I have been able to observe, in the mortality. When I left home there was practically no difference between our brook trout fingerlings and brown trout fingerlings of the same age. So far as the stocking of streams

is concerned I have found that there has been a very peculiar change in the attitude of our New Jersey sportsmen. In the first place I think you have got to introduce brown trout slowly in order that your sportsmen may become educated in that respect, because the brown trout is a harder fish to catch. On the other hand, if you take \$10,000 and spend it in the propagation of brook trout and take the same amount and spend it in the propagation of brown trout you will in the latter case give the sportsmen about three times as much for their money as in the other. And after all is said and done there is no difference in the gameness of the two species so far as we have been able to observe in New Jersey. Three of our commissioners have made a very careful study of the fishing conditions and they have practically decided that, taking all things into consideration, the brown trout is going to give the sportsmen far more for their money even when planted in real brook trout streams.

MR. TITCOMB: Has Mr. Hayford used the progeny of these crosses for breeders?

MR. HAYFORD: We are simply in the experimental stage. This fall we are taking the eggs from the third generation.

MR. TITCOMB: That is, you have got eggs from the cross?

MR. HAYFORD: Yes. This coming year I am also going to run a check with the Loch Leven imported from California as against the cross to see if there is any difference in the fertilization and so forth.

MR. TITCOMB: I think everybody understands that the Loch Leven is an importation from England or Scotland while the brown trout is an importation from Germany. I argued with this man in the Catskills who wanted to stock a native trout stream with brown trout that the native trout produced more sport for the average fisherman than the brown trout. In your stream which is not very large you could probably maintain two or three times as many brook trout as you could brown trout. The brown trout would be larger, but a native trout stream will produce more—in numbers, not in weight,—of the native trout than it will of the brown.

MR. ADAMS: From all we have heard in this discussion it would seem that in a good many streams the brown trout will do better than the brook trout.

MR. TITCOMB: I should expect that in New Jersey the majority of the streams would be better suited to brown trout than to native trout.

MR. MERRILL: In the earlier work with brown trout in Massachusetts there was less difficulty, possibly because the stock was a cross between brown trout which had been brought from New York waters—Caledonia—and Loch Leven that came from New Hampshire, probably from wild stock.

MR. LEACH: There was a time in the history of this country when the brook trout predominated. They were found in streams that were well protected with timber brush—cold, clear water streams—but on account of the inroads of agriculture the ground has been ploughed

up and cultivated; open fields are now found along our streams; the woods have been cut off, and in many instances the stream has changed from a brook trout stream to a bass stream and in some cases to a carp stream. Many of the streams that are in this transitory stage are not suited for the brook trout, and they are the streams in which we ought to stock some other fish that will thrive. The brown trout and the Loch Leven have been found to thrive where the brook trout will not live under the changed conditions brought about by civilization. I doubt whether in this country we do have the true strains of brown trout, so that when you talk about crossing the eastern brown trout with the western Loch Leven you are crossing western fish with eastern fish, the same as you would cross rainbow trout from California with rainbow trout that might be taken in the streams of Maine or New York.

MR. TITCOMB: I think there is no doubt that we have the two species, for they differ; there is variation without question. But the Scotch trout was propagated out there and the brown trout in other places. Some years ago they were propagating the Loch Leven trout out in South Dakota, and it was distinctly a Loch Leven trout.

PRESIDENT EMBODY: We have about reached the time for adjournment. Are there any further matters to be brought up under this head?

MR. TITCOMB: May I read into the record quite a brief statement while Mr. Doze is here; I understand he is leaving to-night. When I said that I would not plant small mouth bass in waters of less than one hundred acres in area in New England, Mr. Doze called attention to the small tanks in his state—I think they call them tanks, do they not?—in which they get a very remarkable production of fish of various warm water species, including the large mouth bass. But my remarks had no reference to those; I was familiar with the results obtained under the conditions referred to by Mr. Doze. But I do not believe a one and a half acre tank will continue indefinitely to produce three different species of fish. I do not believe that even in that wonderful region where they get such remarkable results with large mouth bass a pond of one and a half acres will give continuous production. Up in this country we have so many fishermen that we cannot in small ponds keep up a production of the species which require large range. The bass, our small mouth bass particularly, seem to require a much larger range than any other of the desirable species.

CONSUMPTION, NOT PRODUCTION, IS INDUSTRY'S CHIEF PROBLEM.

BY MR. J. A. PAULHUS.

Mr. Chairman and Gentlemen: When I received from the Honorable Minister of Lands and Forests the flattering invitation to address you at this convention, I thought that it would be of interest to you to hear of my observations and experience with regards to fish consumption in general, and how I could associate publicity with it. I do not pretend that this lecture will be very illuminating to a gathering of men of science, and I immediately apologize for it, asking you only to consider this work on the merits of my honest effort to help a cause, to which I have devoted many precious moments of study and reflection.

Within recent months I have been given an opportunity to make some observations abroad, and having an instinctive fascination for things pertaining to fish and fishing I was strikingly impressed by the fact that the countries of continental Europe are not essentially fish eating peoples. In these countries the consuming elements are the two extreme classes—the impoverished, and the opulent—the first for the reason that fish provides a sound, satisfying nourishment, and possibly the only basic nourishment to be procured by their limited means, and which explains in a way our exports of dried and canned fish, particularly the cheaper grades to countries like Italy, Spain and Greece.

In certain sea ports where local fishing operations are performed, the same rule applies. When the catch is sufficient to depreciate prices, then the fish is bought by the small purse folks; if there is a scarcity, it is the privilege of the well-to-do to make use of it.

The intermediate masses, generally styled the middle class, does not eat fish, and inasmuch as this comprises the bulk of every country, it may readily be grasped why fish is not more generally used.

My impression of France in this matter is a little more hopeful. This country is endeavoring to promote and encourage fish distribution and consumption. Only lately an inquiry was ordered through the Government to ascertain what was the quantity of fish served in all the military barracks and institutions depending on the State budget for their maintenance. This, as may be seen, was a move in the right direction. During the past few years the building of cold storage plants together with the improvements carried out in the fishing ports and with a certain educational effort towards

increasing fish production and marketings, give promising evidence that the French people are devoting a greater interest to fish than theretofore, and evidently intend to spend more on the sea to supplement the shortage of land production in the matter of foods.

One must travel to the "Tight Wee Island," the cradle of that virile, broad-minded, deep-visioned race which is the mighty backbone of the vast British Empire, the keystone of modern civilization, to come into an atmosphere congenial to the lover of fish activities. Let one land in a fishing port like Grimsby or Lowestoft. Here the sight of the docks lined up with numerous craft of fish loading and unloading is a sight that a true lover of seascapes and fish lore cannot fail to view with a gladdened eye. If England has taught a lesson of ingenuity and resourcefulness to its neighbors, it is without doubt in the way she gathers and distributes these immense sea fares.

We find there a people who make fish a staple of their diet—a people who with the exception of the Japanese consume more fish per capita than any other nation in the world. The reason therefor is not difficult to explain. One finds everywhere a thorough appreciation of the merits of fish foods. It does not require a very keen observation to find that this appreciation is born of long-existing, and widespread educational propaganda.

The proof of this is striking if one roams around the country for a short time. In every town of more or less importance one will see fish shops as well appointed and as numerous, as meat stands or any other line of foods.

Billingsgate Market in London is as well known and has as much romance attached to its name as the Royal Exchange or the Bank of England. It has its own tradition, ante-dating by far the memory of men and events connected with it from a part of the history of the old city.

Anyone from Canada making observations from my viewpoint could be pardoned a certain amount of pride in the status of fisheries development here as compared with other countries. Comparatively speaking, we in this country have achieved a greater degree of development and established fish more effectively in the national diet than any other country in the world. Comparisons though frequently odious, are in many cases extremely effective in making a point clear, and you will therefore pardon my reference to the great republic to the South of us. Our blood relationship is so close that we may without fear of offense make such comparisons with the same freedom of thought and speech as frequently passes around the family board. While the United States has a

population twelve times that of Canada its total fish production is little more than double that of our country. Furthermore, interior states have a very, very casual acquaintance with sea foods. Assuming that the proportion of fish production entering into domestic consumption is in the same ratio as in Canada, it will be seen that the 110 millions of people in the United States consume not more than twice as much as the nine millions of people in Canada.

Less than a year ago I was invited to attend the annual meeting of the United States Fisheries Association at Cedar Point, Ohio. I motored from Montreal, and while my trip was otherwise extremely pleasant, I was chagrined to note the frequent invitations on billboards and signposts to partake of "Old fashioned chicken dinners," "hot dogs," etc., but not once did I see any similar inspirations to dine on fish, and I came to the conclusion that the old aristocracy of the codfish in the United States had been dethroned by the nobility of the meat packers and the sugar trust. On the contrary efforts to procure a palatable fish dinner—efforts, however, which were not prompted by a desire to criticize, but by natural fondness for fish—were without success. This situation, I must say, however, is not applicable to the entire country. In the states bordering on the sea coast or on the Great Lakes, and in states readily accessible there is a satisfactory distribution of fish, but unfortunately only the outer fringe of the vast market has yet been served. In Canada, I must confess, conditions are much better. There is a more general distribution of fish. While the per capita consumption is no where near what it should be, considering the inherent qualities of the food, and the inexhaustible source of supply, people in all parts of the country are linked up in a vast chain of distribution, which I might say has been extended and improved in no inconsiderable measure through the Canadian Fisheries Association with the co-operation of the Federal Government.

It is like carrying coals to Newcastle to dwell here upon the health-giving qualities of fish, but if you will pardon me I will refresh your memories on a few salient facts. For many years cod liver oil has been a comfort to suffering humanity, and not so long ago it has been discovered to contain in greater abundance than any other food that elusive vitamin A. It is also a cure for the rickets. In recent months it was proved by experiments on rats that it effected an almost immediate corrective. Humanity will always pay tribute to Dr. Banting for his discovery of insulin—originally procured from the pancreas of certain fishes—which promises perhaps within our own generation to banish diabetes from the cate-

gory of human ills. More recently a renowned British scientist has discovered in fish an element which claims to eradicate the scourge of tuberculosis just as effectively as insulin cures diabetes. The value of iodine in the human system to prevent thyroid troubles is well known. In certain parts of the United States urgent means are being employed to insure the absorption of an adequate amount of iodine into the system. In some communities small portions of iodine are being administered regularly, and in others common table salt is being treated with iodine. In these territories—which, be it noted, are places in the United States already referred to, which have not been blessed with regular and adequate supplies of sea foods—authorities seem to have lost sight of the fact that fish is particularly rich in iodine content, in fact more so than any other food, and that the difficulty might be overcome in a less harsh and more palatable way by popularizing the use of fish foods. Statistics indicate that fish is more readily assimilated by the system than meat, and most other foods. Physicians all over the world lay the blame of many ills to an overconsumption of meat and this fact of comparative indigestibility is undoubtedly the reason.

This doctrine of improving health has received a new impulse. Of late it is more than ever preached from the forums of the world. The propagandists of this school of thought, men of science, professors in universities and others, are devoting much time in researches and deep study calculated to improve health and prolong life. From Boronoff, Doctor Banting to Henry Ford, from the grafting of glands, the discovery of insulin to the abstemious Ford regimen all sorts of cures have been devised by both theorists and practitioners.

Nor does it seem advisable in addressing a gathering of scientists to observe that our supply of fish foods is positively inexhaustible. Science tells us that life originated in the sea. Future life was evolution. It is logical to assume therefore that life will continue to exist in the sea when all other forms have vanished. There seems to be a natural balance of sea life maintained by nature. For instance, the eggs deposited by our west coast salmon, from year to year, if they were all permitted to develop and repropagate to their full capacity so that their progeny indefinitely could survive, the lanes of ocean traffic would be actually blocked.

Another way in which the same point may be illustrated is to use the calculations of an authority on Pacific salmon who maintains that the volume of the species finding its way to our canneries equals not more than five per cent of the total destruction of the species through natural causes.

It was not my original purpose to be critical in any way, but I am led to the observation that our Government is spending in excess of three hundred thousand dollars a year in artificial fish propagation. If memory serves me rightly, the output of artificially developed eggs last year approached one billion. This figure appears very imposing, but when one considers that the same amount of propagation may be carried on naturally by a few herrings and a few cod there seems little to justify a continuation of this expenditure. Although isolated cases have been brought forth to prove its efficacy there is little, if any evidence to prove its worth in a broad way.

It is calculated that between twenty and twenty-five millions of dollars have been spent on artificial propagation since its inception in Canada. We have already observed that our supply of fish is inexhaustible, although this naturally does not apply to individual species. Should the natural demand create a "run" on any particular kind of fish and the resource show signs of depletion it would appear more logical to restrict the fishery to enable the species to recover in the natural way. Heretofore political pressure may have been used to prevent restriction of this character, but it is much better and more in tune with our conception of democracy to have the individual suffer rather than the whole—and bear in mind that our fisheries are the property of the state.

There are two points that I have endeavored to impress upon you. One is that our fish resources are beyond our fish requirements. The other is that fish is a highly essential food for the maintenance of a sound health standard. These two facts naturally suggest that we should employ means to bring about a greater use of fish among our Canadian people and the most effective and, to my mind, the only way of achieving this is through the agency of education, and the most effective propaganda is through advertising. The thought must be instilled into the minds of young and old, into the minds of those who are responsible for the mental and physical wellbeing of our Canadian people.

I believe we in the fishing industry of Canada have been the first among all the countries of the world to get together for this purpose. Last year, with the assistance of the Federal Government, the Canadian Fisheries Association launched a national movement which despite its comparative limitations produced splendid results. The movement is continuing this year and will, I hope, continue over a period of years until our people come to use fish on the same scale as the people of Japan who are credited with a per capita consumption in excess of two hundred pounds per year.

I think, in view of the fact that the theory of artificially propagating fish has not proved itself, we might with propriety divert sums now being employed to that end, to secure a thorough and regular distribution of fish throughout all sections of the country. Everybody in Canada, no matter where they live, has an equally just claim on the products of our resources and an equal interest in the comfort they will provide. It strikes me as being a duty of government to meet the situation, not, as you may infer, for the advantage of those employed in the industry, but to furnish all Canada with a means of maintaining good health and cheap food. And also to recover latent wealth from its great natural resource for our fisheries will endure when all our forests have been stripped, when our mines have been made to disgorge all their treasure, and when our great productive areas have been sapped of their vitality.

Discussion

PRESIDENT EMBODY: I am glad that we have been able to hear from the President of the Canadian Fisheries Association on the commercial fisheries side of the matter. I am sure that we are not eating enough fish, and if Mr. Paulhus can suggest any way in which this Society can co-operate with him in remedying the situation I am sure he will find us most willing to help.

MR. TITCOMB: I think we all appreciate having Mr. Paulhus come here and give us that very interesting address. I understand that he had to make a sacrifice to come here to-day—he set the time a long way ahead—and unfortunately it is the day when we have the least number of members present. I endorse everything he said in regard to the importance of fish and the commercial fisheries, but when he intimates that the fish cultural work is not accomplishing anything I have to take issue with him, and I imagine that every member of the Society will do so. I want to ask Mr. Paulhus whether he has actually studied this fish cultural side and its results?

MR. PAULHUS: I am speaking only as a business man. I never saw any reports to indicate that much was accomplished by it.

MR. TITCOMB: I feel as if we should present some points on the other side and not let that feature of the paper go unanswered. I will confine myself particularly to the development of the commercial fisheries. Lake Erie twenty-five or thirty years ago was practically depleted of fish. The United States Bureau of Fisheries, in co-operation with the states of Pennsylvania, New York and Ohio, conducted fish cultural operations very extensively and brought the commercial fisheries back. I never saw a more interesting demonstration of what had been accomplished there than was brought up at a convention of commercial fishermen which I attended, at Erie, Pennsylvania. At that convention

every one of the fish producers, all the big men in the industry on Lake Erie, were very keen about the hatcheries. They wanted us to extend our operations to include more species. Twenty years ago the federal hatchery at Cape Vincent on Lake Ontario was rather under a cloud. It had been operated many years but there had been difficulty in getting sufficient eggs to stock it. That condition is entirely changed to-day, and now the herring, whitefish and lake trout are hatched there in very large numbers, the source of supply being Lake Ontario. The fishery has been brought back. It has not been entirely due to the work of state and federal hatcheries either; it is due also to the work of you people on the Canadian side of the lake. I want to say that we who have come from the states have had our eyes opened here at what you are doing along fish cultural lines, particularly what you have done during the last few years. You have made very rapid strides, and Lake Ontario is one of the places where you are doing very extensive work and getting results.

Now, to come to the question of the game fishes: Mr. Paulhus says that when the forests are gone we will still have the fish. I imagine he is thinking more of the ocean and the Great Lakes than of that vast area of fishing waters here in small lakes and ponds. Take the province of Quebec, with its large number of lakes and ponds which are leased to clubs; they are all showing the ill effects of deforestation followed by forest fires. Some of the most important fishing clubs in this province to-day are right on the ragged edge so far as trout are concerned. You have only to go a little way from the city of Quebec to see streams which only a comparatively few years ago were teeming with trout but from which to-day they have disappeared. The physical changes of the water have made them go. They cannot live in the warmer water, and where deforestation followed by forest fires has swept the watersheds of many of these large areas which formerly teemed with the trout, to-day inferior or useless species have taken the place of the trout and the clubs are wondering what they are going to do and why the fish are gone.

There is a tremendous demand for fish propagation. Money is being expended to operate hatcheries because the people want it, and because they are getting results from it. You can get a great deal more out of fish propagation than otherwise, by conserving the eggs that nature is so lavish with and which without artificial propagation would go to waste. Take the salmon situation on the Pacific coast; your salmon would all be gone without proper regulations; if they were simply allowed to get along as best they could in the streams that would end them. The fisheries of the Pacific coast are being maintained as the result of artificial propagation and without that aid to the regulations the salmon would be gone in many of these streams.

MR. RODD: Mr. Paulhus is apparently not altogether satisfied with regard to the beneficial results of fish culture, but he admits that he has not made any study of the subject.

Mr. Titcomb has referred, amongst other matters, to Lake Ontario. Twenty-five years ago the whitefish fishery of Lake Ontario was considered an industry of the past. In 1922 the commercial catch on the Canadian side was nearly twenty times as great as it was in 1895, or 21,000 cwt., against 1100 cwt. The maintenance or an improvement of the fisheries obtains everywhere that we have made an adequate and systematic distribution of hatchery fry. In the Fraser River, B. C., this condition is quite marked. Above Hell's Gate in the upper waters there are no hatcheries and this region is now in a state of depletion, so far as runs of spawning sockeye and natural propagation are concerned, but in the Harrison-Lillooet lakes district where there are two hatcheries the run of spawning sockeye has been maintained and increased and is now as large or larger than it was twenty years ago.

The records of the Hudson Bay Company, extending back for more than 100 years, show that an enormous or "big" run of sockeye occurred in the Fraser River every fourth year, followed by three lean or "off" years, so that it is obvious that in no reasonable time could natural propagation, unmolested but unaided, bring the "off" or lean year runs up to the volume of the big run of every fourth year.

MR. LEACH: I do not understand that Mr. Paulhus's paper criticises artificial propagation in the same sense that may be inferred from the discussion of it by other members of the Society. With regard to the commercial species there must be some provision for protection, and if this is not done there can be no artificial propagation. As regards the fishes of the Great Lakes the bureau of fisheries places competent spawn takers on as many of the vessels as possible to collect eggs from such of the fish brought aboard as may contain mature eggs. It is not possible to place men on all the fishing boats, neither is it possible to remove the eggs from all fish caught since they are not in spawning condition. The work the bureau is doing is for the purpose of conserving such eggs as are in condition to be taken, sending them to the hatcheries for incubation, and not allowing them to be sent to the markets, where they would be lost in the process of dressing the fish. This applies to practically all the commercial eggs collected by the bureau. It simply means the saving of such eggs as are available.

I therefore contend that protection comes before fish cultural work and if it were not for protection it would not be possible for the bureau to collect eggs from the fish, since they would be taken outside the spawning season. With reference to the propagation of fishes for interior waters, there is no question as to the success that has been attained.

MR. RODD: I would like to refer to the enormous fourth year run in the Fraser River. The records of the Hudson's Bay Company, which go back over one hundred years, show that one hundred years ago there was an enormous fourth year run of sockeye in the Fraser River, followed by three smaller and dwindling runs. That condition continued for a century, and it would seem that nature, unaided, could not bring

the three years up to the fourth, even though no commercial fishing was carried on during that period to deplete the supply. In the lower Fraser, however, we have the hatcheries, and that difference is disappearing. In the Harrison-Lillooet region the fourth year run has been maintained and increased and those of the other years have been increased to such an extent that the difference is becoming less each season.

DR. PRINCE: Mr. Paulhus has been one of the most earnest and active members of the Canadian Fisheries Association and has done a very great work. His interest in these matters cannot be questioned by anybody who knows him. I like also the fine spirit of his paper. True, there are some points about it which are open to discussion, but I think it is well that such papers as this should be presented, to make us think.

Very much more could be done to assist the fishing industry in the matter of bringing fish into the markets in the best possible condition. I am satisfied that Mr. Paulhus has done his share to increase the per capita consumption of fish in Canada, and he has accomplished a great deal; but we still have a long way to go, both in Canada and in the United States, in increasing the popularity of a fish diet.

With respect to the relation of the state to the fisheries, I fully agree with Mr. Paulhus. I wish the people generally could realize, with him, that the fisheries are the property of the whole people. In connection with fisheries administration we will find little localities maintaining what they designate as their rights, claiming the ownership of lobster beds or oyster beds, as the case may be, which happen to be within their particular district. But I feel that even those who live a thousand miles from the sea should be concerned in the preservation and conservation of those fisheries; they are a national possession in which all the people should have an interest whether they live on the sea coast or in the interior districts.

I maintain that we should not preach the doctrine that the hatcheries are the sole solution of the prosperity of the fisheries but should rather recognize that fishery regulations and laws are just as essential. I think my friends who are in charge of hatchery work will readily agree with that. We must not let the idea go abroad that hatcheries can be solely relied upon to maintain the prosperity of the fisheries. In the course of one morning I have seen cod brought into the little port of Perce down the Quebec shore with more eggs in them than all the hatcheries along the Atlantic coast could have produced had they been operating for years. Each cod contained nine or ten million eggs, and while no one will claim that they all produce, at the same time it impresses one with the fact that when you have such an enormous production of eggs in the sea the putting out of a few million fry from the sea fish hatchery is not much more than a drop in the bucket, as Mr. Leach said. I am convinced that hatcheries can do excellent work. New Zealand had no salmonidae many years ago; now a large number

of their rivers are well supplied, and that is a clear proof that the planting of fry has been effective there. But experience has shown that fish hatching can be made a success under one series of conditions and will prove a failure under others, so that we have to take all these things into account. On the whole, however, with both nature and man helping the fisheries we cannot fail.

SKETCH OF THE DEVELOPMENT OF FISH CULTURE IN CANADA.

By J. A. RODD,

Superintendent of Fish Culture for Canada.

Fish Culture in the modern true sense of the term and as an aid to the maintenance and replenishment of the fisheries had its inception in Canada in 1856 as the Commissioner of Crown Lands of Canada in his official report for that year refers to the reduction of the salmon fisheries of what is now the Province of Quebec, and to the advisability of adopting artificial fish culture,—which had previously been attended with success in European countries,—as a means of restoring them to their former value.

FIRST CANADIAN FISH CULTURIST.

The first Canadian Fish Culturist was the late Richard Nettle, of Quebec and Ottawa, who died in Ottawa in 1905. He was appointed Superintendent of Fisheries for Lower Canada in 1857, and that year in answer to a written application therefor, (the Fisheries of the Province of Quebec, by Chambers) he was given permission to resort to artificial propagation as a means of restoring the salmon fisheries to their former value. Judged by present day standards his plant was not large. His official report for 1857 states that "the spawn boxes would contain about 8,000 ova, (portable boxes might be made to contain about 6,000 more within the tank or pond), and the large pond will contain about 10,000 young fish." The water supply was obtained from the aqueduct from the River St. Charles, and the eggs were hatched on gravel in wooden boxes lined with lead or zinc. His first experiments were with trout eggs obtained in the Jacques Cartier River and Lake Beauport, which are both in this neighborhood. The Jacques Cartier River is about twenty-five miles and Lake Beauport about ten miles from Quebec. I understand that these were the first artificially fertilized fish eggs that were successfully hatched in the western hemisphere. The resultant fry were reared and fed on hard boiled liver (pulverized), and small worms from the tan pits, until the fall of 1858 when, —according to his report,—some of them were from three and one-half to four inches in length, and almost as broad as they were long." (Fisheries of the Province of Quebec by Chambers).

In 1858 the hatching boxes which Mr. Nettle terms the "Ovarium" were stocked with salmon eggs (from 7,000 to

In 1856 "Canada" comprised Upper and Lower Canada now the Provinces of Ontario and Quebec.

8,000) from two pairs of salmon taken in the Jacques Cartier River. He states (Fisheries of Quebec, by Chambers) "that his success was all that could be hoped for, and at least seventy per cent of the eggs became young fish." This early pioneer's enthusiasm is indicated by a description in one of his reports of a Cesarian operation which he performed on some salmon eggs,—the shells of which had hardened,—"by piercing the outer shell with a sharp pointed needle taking care not to puncture any vital spot." In 1859 when collecting salmon eggs in the Jacques Cartier River he caught and opened a trout that was following the salmon and feeding on their eggs. The salmon eggs that were found in the stomach of the trout (300 to 400) were carefully turned into a tub containing salmon milt. The best of them were kept in a separate box in the ovarium where they hatched in due course.

Mr. Nettle's operations were continued into the early sixties.

FIRST FISH CULTURAL OPERATIONS UNDER THE DOMINION GOVERNMENT.

Fish cultural operations as a Dominion Government service is as old as Confederation, as in that year—1867—the Department of Marine and Fisheries assisted the late Samuel Wilmot in collecting and hatching the eggs of the salmon which resorted for spawning to the streams that flow to Lake Ontario, but were at that time (1867) rapidly disappearing.

Mr. Wilmot commenced the hatching of salmon eggs, taken in Wilmot's Creek, Lake Ontario, in spring water in his cellar at Newcastle, Ontario, in 1865. In 1866 this creek, at Mr. Wilmot's request, was set apart for the natural and artificial breeding of fish, and that year he secured about 15,000 eggs, which were also hatched in the cellar of his dwelling. The next year he was given some government assistance and secured a larger number of eggs (50,000) than in 1866, but had a larger percentage of loss. In 1868 he was appointed a Fishery Officer "with instructions to apply himself more particularly to the specialty of pisci-culture," and the Newcastle hatchery was built by the Dominion Government.

This appears to be the first regular hatchery of the western hemisphere that was built and equipped at government expense. It consisted of a hatching house and a reception house for the parent fish. The former was about sixty-four feet long and twenty-four feet wide, strongly roofed, with

a stone masonry wall seven feet deep, and so embanked with earth as to form an underground cellar impervious to frost. The hatching troughs,—which were of wood,—extended longitudinally nearly the whole length of this underground apartment. They were twelve inches wide and six inches deep, and laid in a slight decline. They were fed from a water-tight tank at the head, which was in turn supplied from a canal dug alongside of the main stream from a small dam across it, which gave a head for the canal and also turned the salmon into the tail race below, leading them into the reception house adjoining, where they were kept until ripe.

Suitable sites for "reception houses" are not plentiful, and the method was found to be unreliable. It was, therefore, discontinued in 1875 and at the present time parent Atlantic salmon are purchased from the commercial fishermen or caught under contract in nets operated for the purpose. They are retained until they are ripe in tidal ponds at the mouths of small streams.

UNITED STATES ACTIVITIES.

A very active interest was taken in fish culture about this time. Several of the American States were looking into possibilities, and some of their officials visited the Newcastle hatchery and examined the apparatus used and the methods followed there. Dr. Hugh M. Smith, who is well known to most, if not all of you, is my authority for the statement that it was not until 1871 that the United States Congress took the initial step towards a National Fishery Service by creating the office of Commissioner of Fish and Fisheries and the propagation of fish (Dr. Hugh M. Smith's paper read at the Fourth International Fishery Congress, 1908) was undertaken by the Commission in 1872 at the instigation of this society, which was organized two years previously under the name of the American Fish Cultural Association, now the American Fisheries Society.

Some of the States had propagated fish previous to 1872, but it appears from the reports at my disposal that Canada led the United States by four years in fish culture as a Federal Government Service, and Mr. Nettle's operations in Lower Canada preceded state-aided operations in any of the states by several years, so that it would appear that Canada was the pioneer in state-aided fish cultural operations on the American continent.

PRIVATE HATCHERIES.

In the early days of fish culture fertilized eggs and young fish brought good prices, and several private hatcheries were started. In 1871 eyed salmon eggs from the Newcastle hatchery sold in the United States for \$40.00 a thousand. Such prices induced private persons to go into the production of fertilized eggs and young fish as a business.

In 1866 Mr. Fletcher, of New Hampshire, collected salmon eggs in the Miramichi River, N. B., for stocking the Merrimac River, New Hampshire. On account of his method of taking the parent fish,—spearing them on the spawning beds,—his operations were not authorized after the first year. A hatchery was also erected in 1868 at North Esk, on the N. W. Miramichi, N. B., by the Reverend Livingston Stone, of Boston, and Mr. John Goodfellow, of North Esk, on the condition that half of the fish produced would be turned alive into the river, and the balance would be their property. Their operations were little more satisfactory than Mr. Fletcher's, and were soon discontinued.

A private salmon hatchery was erected by the late John Holliday on the Moisie River, Quebec, in 1859, and was continued by the Holliday family as long as it held the fishing rights in the estuary. Their hatchery was operated for over fifty years, and was discontinued in 1912.

David Brown and others operated a trout hatchery at Galt, Ont., and in 1870 had as many as 10,000 parent trout in the main pond, besides fry and fingerlings. Some of these early fish farms are still operating in Ontario and, as the members of this society know, there is quite a large number in the United States.

EARLY EXPANSION.

Mr. Wilmot was most enthusiastic, and rapidly extended his experiments to the hatching of the more important food fishes. He was at least one of the first, and he claims to have been the first to have successfully hatched whitefish eggs in 1868-69. Salmon trout eggs were collected in 1869 and were successfully hatched in 1871-72, speckled or sea-trout in 1876-77, pickerel in 1881, Pacific salmon in 1884, and lobster in 1891. Parent bass were retained and reproduced naturally in ponds at the Newcastle hatchery in 1872.

In 1876 there were seven hatcheries in active operation, with a yearly output of over 9,500,000 fry, and Mr. Wilmot was appointed the first Superintendent of Fish Culture, which position he held until 1895 when there were 15 hatcheries in operation with an output that year of 254,000,000 fry.

EARLY APPARATUS.

As is usual with all new ventures or undertakings, the apparatus used and methods followed by the pioneers were changed as greater experience was gained.

In his earlier experiments Mr. Wilmot endeavoured to follow nature as closely as possible in taking and fertilizing the eggs, and one of his methods was to strip the fish under water. The wet method of fertilization was generally practised, and the eggs of the female were stripped into as large a body of pure water as could be conveniently arranged for the purpose, and to this the milt was afterwards added. In 1870 Mr. Wilmot endeavoured to get still closer to nature and arranged in the creek a spawning bed of gravel, where he hoped that the fish would spawn and the eggs be fertilized in the natural way. The spawning bed was composed of gravel placed on a wire grating, and it was planned on the principle that in the act of spawning the gravel would be more or less displaced by the fish, and the fertilized eggs would drop through the gravel and the wire grating on to an endless canvas apron on rollers, from which by turning a crank the eggs could be deposited in a pan or trough as desired. This apparatus was enclosed in a building 66 feet long, 15 feet wide, and 12 feet deep. The water supply was regulated by gates and taken from the main creek. This method was apparently followed for only one season. For the first years the eggs of both salmon and whitefish were carried during the hatching season, on grills made of double rows of glass rods in a small wooden frame sufficiently close together for the eggs to rest on the rods without falling through. The glass grills were soon replaced by finely perforated zinc pans and trays made with a wooden frame and bottom of woven wire cloth, and these pans and trays were subsequently replaced by the trays,—made out of one piece of perforated tin or zinc pressed into the exact size and shape desired,—and the wire trays and baskets that are now used. Rectangular earthenware plates and saucers were used for a time in some of the Atlantic salmon hatcheries, but were inconvenient and cumbersome, and were not replaced as they became defaced

or were broken. In the early days the zinc and wire trays were covered to a depth of half an inch with well washed and screened gravel with a view to simulating natural conditions in the streams, and to prevent the eggs from coming in direct contact with the metal of the trays. The gravel, on account of its tendency to collect sediment, made it difficult to keep the eggs clean and after due experience was dispensed with, and a thorough coating of the trays with coal tar or asphaltum varnish was adopted.

In the experiments with whitefish eggs, glass grills and trays were used, but when the first large whitefish hatchery was built at Sandwich on the Detroit River it was equipped with troughs twelve feet long by twelve inches wide, and ten inches in depth, and divided into a series of compartments fifteen inches long. Eight, ten or more hatching trays, one upon the other, were placed in each compartment. Between each compartment in the trough there was a space of three inches through which the water could be made to flow either upwards or downwards through the eggs at pleasure, by reversing the troughs end for end upon the staging which supported them. This space of three inches had a hole and a plug in the bottom, and was also used to draw off the water and sediment from each compartment without enterfering with the adjoining one. The troughs were placed one after the other lengthwise of the room, and connected by short pieces of rubber hose let into the ends of each of them.

The trays and troughs were soon replaced by an invention of Mr. Wilmot's which in 1876 he patented in Canada and the United States under the name of "Wilmot's combined fish egg incubator and self picker of eggs." As first patented the eggs were retained in tin or metal receptacles, but in 1881 these receptacles were replaced in the Sandwich hatchery by glass jars, which in various forms are now in general use for hatching whitefish and other semi-buoyant eggs.

The principle was the same in the original tin vessels as it is in the modern glass jar, but the glass jar is much the better of the two as the motion and working of the eggs are readily seen in it.

Our modern whitefish jar is fitted with a removable overflow screen and is graduated in quarts, and fractions thereof, so that the number of eggs in a single jar or hatchery is readily determined at any time without taking the jars off the batteries.

In 1872 Mr. Wilmot was awarded a First Class medal by the Acclimatization Society of France for "his achievements

in the work of Pisciculture," and in 1883 a complete working section of the system of hatching in vogue in Canada at the time was put in operation at the Great International Fisheries Exhibition in London, where it carried off the highest award, namely, the Gold Medal and Diploma for the best and most complete fish breeding establishment in the exhibition.

The following awards were also won by the Canadian exhibit:

Young salmon hatched out from eggs brought from Canada and grown to a length of from 4 to 6 inches in the troughs during the time of the exhibition. **Gold Medal and Diploma.**

Model of salt-water pond as used in Canada, for retaining parent salmon from June till ripe. **Silver Medal and Diploma.**

Working model of fish-breeding establishment as used in Canada. **Silver Medal and Diploma.**

Live fish and egg carriers. **Bronze Medal and Diploma.**

As was previously stated, during his earlier experiments, Mr. Wilmot endeavoured to follow nature as closely as possible, and placed the eggs of the fish as they were stripped in as large a body of pure water as could be conveniently arranged, and afterwards added the milt of the male fish. In later experiments he found that by using a smaller quantity of water with the eggs he obtained better results, and in 1871 adopted the dry method of fertilization, which has been since followed, and about that time was adopted by most fish culturists.

The expansion with regard to the enlargement of the older hatcheries and the erection of new ones has been gradual and healthy. The greatest expansion took place during the years immediately preceding the outbreak of the Great War. In 1914 three large whitefish hatcheries were built and put in operation, but since that time the funds necessary for further expansion in the way of main hatcheries have not been available although several small and inexpensive sub-stations for egg collecting and fry distributing purposes have been opened.

The expansion and development of the service since its inception is indicated by the following statement.

Statement

showing the numbers of fresh-water and anadromous fish distributed and the numbers of such hatcheries in operation in the years indicated.

Year	Number of Hatcheries for fresh-water and anadromous fish in operation.	Number of fresh-water and anadromous fish distributed.
1876	7	9,655,000
1886	12	76,714,000
1896	13	102,459,500
1901	9	93,540,000
1906	21	182,052,000
1911	32	416,326,257
1914	43	507,987,785
1917	44	879,335,704
1920	41	750,386,790
1921	43	845,856,651
1922	43	878,987,093
1923	41	886,990,350

The decrease in the number of hatcheries operated from 44 in 1917 to 41 in 1923 is explained by the closing of the establishments for the propagation of game fish in Ontario, and the transfer of the hatcheries in Quebec to that Province.

The fisheries of Ontario are owned and administered by that Province. The Province attends to the propagation of fish for stocking the smaller lakes and waters resorted to for angling and the Dominion attends to the propagation of the commercial species for stocking the Great Lakes and the Lake of the Woods.

The non-tidal and non-navigable (from the sea) waters of Quebec are owned by the Province. The fisheries in tidal waters and waters that are navigable from the sea in Quebec are by Privy Council decision vested in the Dominion but the land under such waters is owned by the Province. By agreement between the two Governments (Dominion and Provincial) which was confirmed by Order-in-Council, the administration of the fisheries of Quebec, including the hatcheries, was transferred to the Province.

The greater part of the hatchery output is distributed in a free swimming stage and after the food sac is absorbed as the early establishments were not located with a view to rearing beyond the fry stage. The facilities available at the various hatcheries for feeding and rearing fish are being developed and the distribution of "fingerlings" and older fish was increased by twenty per cent, with a total of thirty-five and one-half million, during last year. The expansion in this direction during the last three years was as follows:

	Number of fingerlings and older fish distributed.
1921	22,253,000
1922	28,672,900
1923	35,412,000

Another recent departure is the distribution of fry in barren lakes from which mature fish are shut off by falls or other obstructions. Lakes of this nature are really natural retaining ponds on an extensive scale.

So far as is feasible the distribution is arranged on a "standard" basis. Streams are examined and classified according to their physical condition, the extent to which they are fished, and their general value from a fish-producing standpoint. They are put in three classes as follows:

(1) Streams rich in food, usually with gravelly bottoms, some shade from alders and the like, and an abundance of aquatic vegetation.

(2) Streams with bottoms composed mostly of coarse gravel and with a moderate amount of vegetation.

(3) Streams with bottoms composed mostly of sand and bed rock and with little or no vegetation.

Each class is further sub-divided into three grades, viz:

(a) Streams that are fairly well supplied but heavily fished.

(b) Streams that are approaching depletion.

(c) Streams fairly well supplied but not heavily fished.

The standard for the lake distribution is 1,500 fry for each acre of suitable bottom. The standard also calls for the distribution of the fry in the headwaters of the smaller tributaries, yearlings in the larger tributaries and the intervening sizes to suit the area that is being stocked.

Our "standard" is based on the standard of the State of New Jersey, which was modified to suit our different climatic conditions and changed in accordance with our own experience in stocking lakes. I am greatly indebted to my friend, Mr. Charles Hayford, of Hackettstown, for the full and complete information and particulars regarding the New Jersey standard that he very kindly supplied me with some years ago.

While experience may show that our standard may not be the best, it is on a definite and business-like basis, and calls for an examination or study by the hatchery superintendents of the waters in their respective distribution areas. It also assures a widespread distribution which is so necessary in the interests of good results.

Since its inception the Canadian Fish Cultural Service has given almost its whole attention to the propagation of the more important food fishes such as Atlantic salmon in the Eastern Provinces; whitefish, salmon trout and pickerel in Ontario and the Prairie Provinces, and Pacific salmon in British Columbia, but with the more general use of the automobile and the construction of highways and improvement of the roads, waters that were previously remote have come within reach of a largely increased number of anglers and the toll taken by them of the different species of trout

has greatly increased in recent years. Hence the propagation and distribution of speckled, rainbow, cutthroat, and kamloops trout is receiving more attention. The distribution does not include any marine species and is still predominately in favor of the more important fresh water and anadromous food fishes.

Some of the more important food and game fish are becoming established in waters to which they are not indigenous. Spring salmon of the Pacific have been caught in Lake Ontario in various stages of growth from the fry a few weeks old to mature fish in spawning condition, over twenty pounds in weight. Eastern whitefish up to four and one-half pounds in weight have been caught in British Columbia lakes. Black bass from the East are firmly established in Christina Lake in Southern British Columbia and in several lakes in Vancouver Island and other selected waters of the Province are now being stocked from these sources. A similar situation as regards bass exists in New Brunswick. Nearly one million speckled trout eggs were obtained last autumn from two small lakes near Nelson, British Columbia, that were stocked with the species only a few years ago. Atlantic salmon of various sizes, from fingerlings to fresh run fish in prime condition, and kept on their return to sea after spawning are being caught in the Cowichan River, British Columbia.

Rainbow trout are being planted in the streams on the Eastern slope of the Rocky Mountains in Alberta and experimental plants of the same species are being made in Nova Scotia and of Brown and Loch Leven trout in Loch Lomond, N. B. Experimental plants of lake herring from Lake Ontario and Lake Superior have been made in two alkaline lakes in Saskatchewan.

Standard plans, with possible modifications to suit local conditions are followed in the construction of hatchery buildings, and equipment. The center aisle has been adopted for salmon and trout hatcheries.

The method followed in providing space for fry in excess of the hatching troughs is largely determined by the nature of the soil and other considerations. Outside tanks, concrete pools and earthen ponds with sides graded to a natural slope or held in place at the top with wooden plank- are used, as local conditions render advisable.

New ideas regarding equipment are thoroughly investigated and all apparatus and utensils that are found to have a useful place in fish culture are standardized as they are perfected. Our wire hatching baskets which is a develop-

ment of recent years, is now in general use. Each basket holds two trays and eggs are carried in the bottom of the basket and in each tray until they are on the point of hatching.

A deep floating tray and a hatching float which were perfected last year, also have a useful place. The former is useful for carrying fry in their early stages in comparatively deep tanks and ponds, and the later has proved satisfactory and efficient for eyeing eggs obtained at remote and isolated collecting points from which they could not be transferred in a green state without risk and loss.

The floating tray is also a recent development, and as its name implies it floats just short of being submerged. It is only used in the hatching troughs to carry eggs that are on the point of hatching and young fry in the sac stage. During this period they prevent crowding and as they enable fry to be carried at two different levels in the water, the fry carrying capacity of a trough is practically doubled with their use.

The distributing can or barrel is necessarily resorted to in many instances for conveying the fry from the hatcheries to the planting grounds, but this method has been discarded in favor of "Distributing Scows" whenever conditions permit. These scows are so constructed that they ride the waves and do not become submerged when towed against a current. The current of water passing through them is controlled and regulated by valves.

The fry are run by means of hose from the hatchery tanks into the scows, and their escape therefrom on the distributing grounds in such numbers and at the points desired is controlled by screens. Almost the entire production of whitefish, salmon, trout and pickerel, a large portion of the Pacific salmon and some of the Atlantic salmon are distributed in this way.

The operating expenses are met from an annual appropriation by Parliament. Such casual revenue as occurs from the sale of hatchery output to private persons or for privately controlled waters, or of fish caught in nets operated by hatchery employees, is deposited to the credit of the Receiver General, and eventually goes into Consolidated Revenue. The appropriation for the current fiscal year is \$370,000.00. As this appropriation meets the salaries and wages of the staffs, as well as repairs and operating expenses, we are somewhat cramped for funds, and our hatcheries are unable to adequately cover even the older and more settled provinces and in the newer provinces, par-

ticularly in the mountainous, regions we are unable to reach many extensive areas from existing establishments.

While Canada took a leading place in fish culture in its pioneer days in the western hemisphere, she was soon outstripped by the United States Federal Service in the number of hatcheries and the magnitude of distribution. I believe, however, that I am safe in saying that at the present time our service is second only to that of the United States in the number of hatcheries operated and in the volume of distribution.

Our hatcheries are classified in accordance with their importance and the work that is done at them, and placed in four grades. The permanent staff at each consists of one superintendent, one or more assistants and helpers, and temporary employees as required. All appointments to permanent positions are made on a competitive basis by the Civil Service Commission. Selections for temporary and short-term employment are made by the department under civil service regulations. For inspectional purposes the country is divided in three districts with a district inspector for each one and a chief inspector with headquarters at Ottawa.

At the present time we are operating thirty-three main hatcheries, nine sub-hatcheries, four retaining ponds for parent salmon, several egg-collecting and one eyeing station. The output from these establishments for 1923 amounted to nearly 900,000,000.

As I have already intimated the late Samuel Wilmot was the father of fish culture in Canada as a federal government service. When he retired in 1895 the service was directed by Dr. E. E. Prince, F. R. S.—who was also Commissioner of Fisheries,—until Lieutenant Colonel Cunningham was appointed Superintendent of Fish Culture in 1904, and he in turn was succeeded by the writer in 1911.

While the efficiency of fish culture in general has its critics, it is an indisputable fact that is apparent to all fair-minded and unprejudiced persons that the fisheries of this country have been maintained or increased in all waters that have been systematically stocked with hatchery fry. I shall not weary you with details as I am quite sure that your experiences have been similar to ours, but shall refer to the Fraser River only as it is of international importance. As you all know the enormous fourth year sock-eye fishery of this system has not existed for some time, but in the Harrison-Lillooet Lake district of the lower Fraser

below Hell's Gate,—where there are two hatcheries the run has not only been maintained but it has been increased to a large extent, and at the same time the extensive spawning grounds of the Seton-Anderson lakes; the Chilco Lakes; and the Quesnel Lakes regions above Hell's Gate where there are no hatcheries have become practically depleted.

BARREN LAKES OR NATURAL NURSERIES FOR FRY.

By J. A. RODD,

Superintendent of Fish Culture for Canada.

Fish foods and the feeding of fish is one of the greatest of the present day problems of fish culturists. A properly balanced ration that contains all the elements that are necessary to produce a vigorous, healthy and continued growth and at the same time is not too expensive in its initial cost and in labor preparing it, is one of the things that a great many of us are looking for. The difficulties in this connection are not so serious at the hatcheries that are situated near centers of population, where supplies of cheap fish, beef and sheeps' plucks and the by-products of canning and packing houses, are obtainable in large quantities. It is a different matter at isolated plants where only local supply of fresh fish consists of such coarse fish as can be caught by the hatchery employees. We have several sockeye salmon hatcheries that are so situated. Transportation of fish food from outside points is so costly as to be prohibitive, and it is not feasible to deliver the food in a fresh or frozen state; consequently the feeding of fry in ponds or artificial enclosures is confined to such numbers as can be kept in a vigorous, healthy condition on the natural food found in the water, supplemented by preserved or concentrated food, such as fishotein, halibut meal, and canned salmon and whale meat.

The hatcheries to which I refer are situated in the mountainous regions of British Columbia, where there are many small lakes on the tops of the hills or in pockets in the sides of the mountains. Some of these are cut off from lower level waters by falls that are impassable to the ascent of fish. They are consequently barren as regards fish life, but are literally teeming with the natural food of salmon fry. Such lakes are in effect natural rearing ponds on a most efficient and extensive scale.

As we have found such lakes in British Columbia only, our experiences with them has been principally with sockeye salmon, although there does not seem to be any good reason why they should not be equally efficient with other migratory species that leave their early haunts or nurseries when they are one year old, as their migration as yearlings leave these lakes free for the sustenance of each succeeding season's crop of fry.

We have taken pains to avoid stocking in excess of the natural food supply, which in most instances is quite large. Thus in Crawford Lake we distributed in,

1921	200,000
1922	520,000

During the migration in May following (1923) the outlet creek was literally full of yearling sockeye all in splendid condition and from four to five and one-half inches long. In view of the growth and condition of these yearlings the distribution of fry in 1923 was increased to 650,000. The resultant yearlings this year (1924) were almost, but not quite as good as those of 1923, and the distribution (1924) was decreased to 570,000. Crawford Lake covers approximately forty-two acres and its greatest depth is thirty-seven feet.

Water-lily, another lake in this district, contains about twenty acres, and is from five to six feet deep. The fry leave it about one month after they are distributed. Their growth in this lake is also vigorous and healthy. Specimens from Rainbow Lake, at seven weeks are almost equal in size to those that leave Lakelse Lake, Skeena River; and Owikano Lake, Rivers Inlet; as yearlings.

There appears to be no room for doubt that these so-called "barren" lakes are superior to any artificial enclosure, as there are no construction costs to start with beyond a possible cleaning of the outlet streams and in some instances the providing of a sluice or fishway to facilitate the passage of the fish in their descent, and no after expenses for food or labor in feeding.

THE SANITARY WATER BOARD OF THE COMMON- WEALTH OF PENNSYLVANIA.

BY NATHAN R. BUTLER,

Commissioner of Fisheries, Member of the Board.

Cooperation of the State with its citizens, municipalities and industries together with coordination of several governmental agencies is the way Pennsylvania plans to control pollution of streams in order to conserve and utilize the water resources of the Commonwealth.

To this end Governor Pinchot proposed and the Legislature created the Sanitary Water Board, by Act approved June 9th, 1923, P. L. 489, which is vested with the administration of the anti-stream pollution laws of Pennsylvania and given power to investigate ways and means of preventing pollution of streams detrimental to the public health of animals, fish or aquatic life, or detrimental to the use of waters for recreational purposes.

The Board consists of the Commissioner of Fisheries, the Secretary of Forests and Waters, the Attorney General, the Chairman of the Public Service Commission and the Secretary of Health as Chairman.

The powers and personnel of the Board has made it practicable to lay out a broad comprehensive program for the regulation and abatement of harmful stream pollutions.

The fundamental policy of this program was established by a resolution of the Board adopted on August 8, 1923 which is as follows:

CLASSIFICATION OF STREAMS

"WHEREAS, The degree of pollution of the waters of the State varies widely from the pristine purity of a small stream flowing through a virgin forest to the grossly polluted stream draining a valley given over to intense municipal and industrial development, and

WHEREAS, Such differences in condition and the present and probable future use of the streams must be recognized in determining the required degree of treatment of sewage and industrial wastes, and

WHEREAS, The natural powers of streams to inoffensively assimilate and dispose of polluting matters by dilution must be utilized so far as compatible with the general interests of the public in order to establish a practicable and economical program for stream control, therefore

Resolved, That the waters of the State be classified as follows:

RELATIVELY CLEAN AND PURE STREAMS

CLASS "A"

Streams in their natural state probably subject to chance contamination by human beings but unpolluted or uncontaminated from any artificial source, hence generally fit for domestic water supply after chlorination, will support fish life and may be safely used for recreational purposes.

STREAMS IN WHICH POLLUTION SHALL BE CONTROLLED

CLASS "B"

Streams more or less polluted, where the extent of regulation, control, or elimination of pollution will be determined by a consideration of

- (a) The present and probable future use and condition of the stream;
- (b) The practicability of remedial measures for abatement of pollution, and
- (c) The general interests of the public through the protection of the public health, the health of animals, fish and aquatic life, and the use of the stream for recreational purposes.

CLASS "C"

Streams now so polluted that they cannot be used as sources of public water supplies, will not support fish life and are not used for recreational purposes and also from the standpoint of the public interests and practicability it is not now necessary, economical or advisable to attempt to restore them to a clean condition; and further,

Resolved, That all artificial pollution of Class "A" streams shall be prohibited and any sewage or industrial wastes on the watershed shall be treated to such a degree that the effluent shall be practically free from suspended matter, non-putrescent and disinfected and that recreational use shall not be sanctioned within prejudicial influence of waterworks' intakes, and further,

Resolved, That the degree of treatment of sewage and industrial wastes discharged into Class "B" streams shall be determined for each particular stream or portion thereof after consideration of the general interests of the public and the economies of the particular case, and further,

Resolved, That sewage and industrial wastes may be discharged into Class "C" streams; provided, however, that such discharges shall not create any public nuisance or menace to health."

Wardens of the Board of Fish Commissioners, Rangers of the Department of Forests and Waters, and to a minor extent, Engineers and Health Officers of the Department of Health, in connection with their regular duties, are travers-

ing the streams in the northern, eastern and southern counties of Pennsylvania and indicating on maps, streams found to receive artificial pollution.

These maps, from time to time, are submitted to the Sanitary Water Board and the streams shown by these field surveys to be free from artificial pollution are designated and are thereby allocated for fishing, recreation, tion.

So far, 3,450 miles of such streams have been thus designated and are thereby allocated for fishing, recreation sources of public water supply and like use. As the work progresses many times this mileage will be added to the Class "A" streams of this State.

In connection with this survey the first source of pollution of otherwise clean streams is being reported and the Board is using its best efforts to secure the abatement of such pollutions in order to extend the limits of cleanliness of Class "A" streams.

One of the causes of pollution of streams is the discharge of untreated sewage. Recognizing the financial limitations of municipalities to carry on all their manifold obligations, the Board is endeavoring to secure the cooperation of the town officials by agreeing to definite programs for the progressive construction within a reasonable number of years of intercepting sewers and sewage treatment works necessary to cause an abatement of pollution.

Experience has shown that this procedure is more fruitful of results than an arbitrary requirement to forthwith install all the necessary sewerage works which might require an immediate expenditure of funds beyond the municipality's ability.

The degree of treatment of sewage is determined by the use and condition of the stream.

Greater pressure is exerted and quicker action is required in the cases of municipalities situate near the headwaters of streams than upon those lower down stream in accordance with the policy of extending the limits of the cleaner headwaters.

The industrial waste pollution of streams has for long years been a matter of controversy and even antagonism between the governmental authorities administering anti-pollution laws and the industries, and while progress has been made in the abatement of some industrial waste pollutions, it has not made noticeable improvements in the condition of many streams flowing through industrial areas.

The Board believes that some industrial wastes contain recoverable by-products of value and the discharge of such wastes not only constitutes a financial loss to the industry but simultaneously is the cause of detrimental stream pollutions. The Board also believes that there are certain industrial wastes for which reasonable and practicable methods of treatment have not been found because practical and extensive full scale investigations have not been conducted.

Obviously, it cannot be expected that any one industrial establishment will spend its own funds to conduct such investigations for the benefit of its competitors and the public.

Hence, it appears that the way to approach the problem of the industrial waste pollution of streams is through cooperation with the major industries in groups.

A notable instance of the success of this policy is the case of the sole leather tanneries of Pennsylvania.

There are about seventy tanneries in Pennsylvania, many of them being the cause of stream pollution and some connected to public sewer systems.

The Board invited the executive officers, engineers and chemists of sole leather tanning companies to sit in friendly conference with the Board and as a result the conferees approved a form of agreement which provides for the raising of a fund of \$35,000 by the participating companies and that the Sanitary Water Board shall contribute to this fund a sum not less than 10 per cent of any fund made available by appropriation of the Legislature for cooperation with industry.

These funds will be expended by a Supervisory Committee of engineers and chemists of the tanning industry with the Chief Engineer of the Sanitary Water Board as ex-officio Chairman, in conducting full scale experiments at some tannery to determine the most economical, reasonable and practicable means of disposing of tannery wastes and the agreement provides that the bona fide installation and operation of disposal plants for tannery wastes of such types as may be found by the investigation and upon plans approved by the Board, will be deemed compliance by the tanners with the requirements of State law.

It is intended to offer similar proposals to other industries, such as milk products, paper making, chemical works, etc.

The magnitude of the task confronting the Sanitary Water Board can be appreciated when it is known that there are about 100,000 miles of named streams in Pennsylvania and that the total average flow of Pennsylvania streams is at the rate of 2,600,000,000 gallons an hour.

It has been estimated that stream pollutions may be caused from about 2,500 industrial places representing a capital investment of \$1,000,000,000 and yielding products valued at over \$1, 500,000,000 a year.

Hence the solution of the problem confronting the Sanitary Water Board must be approached sanely and deliberately, with recognition of the financial aspects so as to successfully carry out in an orderly and logical sequence, a comprehensive, practicable program, for control of stream pollution in the Commonwealth of Pennsylvania.

A CONFIRMATION OF BORODIN'S SCALE METHOD OF AGE DETERMINATION OF CONNECTICUT RIVER SHAD.

BY R. L. BARNEY,

Middlebury College.

Recent investigation has indicated that suitably chosen scales of the shad *Alosa sapidissima* may be used in age determination for this species. According to Borodin, the age of shad in years is one-half the number of so-called transverse grooves on the scales. As this is a new method of age determination, confirmatory evidence appeared to be desirable. This led to a study of the otoliths of shad to determine, if possible, the accuracy of the method. The otolith has been of unquestioned usefulness in age determination of a number of species of fish and it seemed that it might, therefore, serve equally well for the shad.

Accordingly a large number of shad of various sizes and of both sexes were collected during the spawning migration of 1924 at several points in Connecticut, the Salmon and the Farmington Rivers. The last two are tributaries of the Connecticut. These collections have been supplemented by a few fish taken in Long Island Sound at other seasons. Records of length, weight, sex, and sexual condition were made for each fish. The age of each fish was also estimated by examination of the scales according to Borodin's method. The otoliths were then dissected from each fish.

The otoliths of the shad may be easily dissected out by cutting off the upper part of the skull so that the cerebellum is laid bare. This cut is made from a point just above the eyes parallel to the long axis of the fish. The entire brain may be removed through this dorsal opening. Removal of the brain uncovers the inner ear. Careful lifting of the tissues on each side of the brain cavity causes the semi-circular canals to break and allows the sacculi containing the otoliths to be dislodged from their bony recesses in the floor of the brain case. The otoliths are very delicate and are broken if not handled with extreme care. Because of their small size and because they are enclosed in the translucent pink tissue of the sacculus they may be easily overlooked.

The otolith of the shad is a minute bone of roughly sculptured surface and of unusual shape. In a shad 14 inches long the bone is of irregular, oval shape with two short sharp points on the anterior end (Fig. 1). In the larger fish these

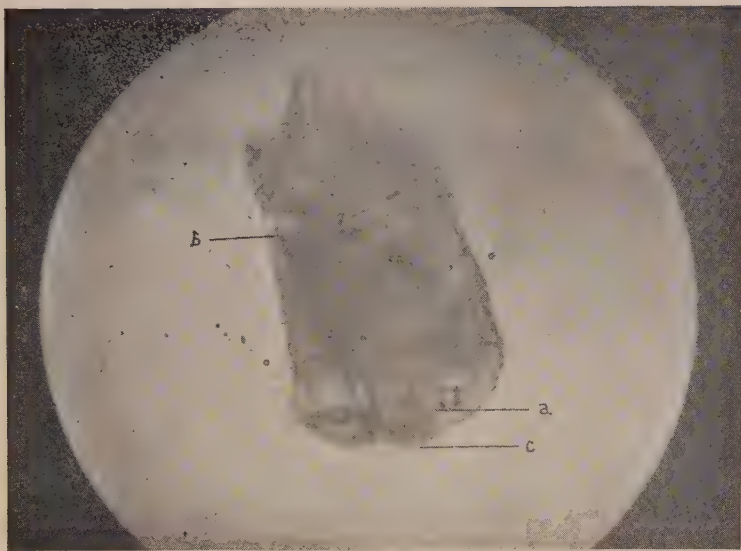


Fig. 1.

Otolith of Shad No. 112 taken at Orient, Long Island, N. Y., June 18, 1924. Length of fish 14.3 cm. Note annulus (a), nucleus (b), and base margin (c).

points become unequal extensions or processes of the bone. In shad of four or more years the otolith is divided into two unequal parts by a deep groove running lengthwise of the bone. The relation of the parts gives the bone a notched appearance. One of the divisions becomes much longer than the other. An otolith, if allowed to dry, becomes very brittle and usually cracks along the groove. The "ear stone" of the shad has a shelving appearance due to successive bony accretions. It is slightly concave. The concave surface is comparatively smooth. The convex one varies. In an otolith whose length is 1.4 mm., the convex surface is a single rough ridge. Otoliths of fish of four or more years have a rough ridge extending the length of each of the two parts of the bone. The lateral margins of the older otoliths are rather deeply but smoothly scalloped. The basal or posterior end is smoothly rounded and somewhat heavier than the rest of the bone. The otoliths of the adult shad rarely reach a length of five millimeters. Taken fresh from the head of a fish they are opalescent. They are also somewhat whiter than the other skull bones. The deposition of new bone occurs for the most part on the concave surface, each new layer extending slightly beyond the edge of the previous one. This manner of growth of the otolith tends toward making it essentially pyramidal in plan. Near the notch between the processes of the otolith is the center of growth around which are numerous fine concentric lines. Around this point the earliest deposits of bone are laid. The center of growth is termed the nucleus in this paper. It persists throughout the growth of the otolith and is useful in measurements.

The shad otolith is not amenable to common histological treatment. If placed in nitric acid as weak as 0.25 per cent, it dissolves with effervescence rather than decalcifies. Evidently the bone is almost made up of calcium carbonate with but a minimum of organic material interspersed. This is the more evident when the bone is stained and examined in ground sections or in toto. Sections of otoliths prepared by grinding are unsatisfactory and stains are of no benefit except as they improve lighting effects. The mineral nature of the otolith and its lack of organic matter capable of differential staining make impossible the use of otolith sections for age determination. Preparations mounted in toto in balsam without staining have been the most satisfactory. Examination of the bone in water or dry is of little value unless the bone has just been taken from the fish, for it becomes white and opaque very soon after removal from the sacculus.

Microscopic examination of sections or of entire otoliths under low power shows numerous rings of growth due to the successive accretions of mineral matter. At first glance, the "rings" or bands appear indefinite. The accretions seem to be laid on without apparent regularity. This impression is lost, however, when it becomes evident that otoliths vary considerably and uniformly with the size of the fish. Comparison of otoliths of shad of various sizes and of various ages, as estimated by scale characters indicates that there is regularity and uniformity in the process of deposition upon the otolith.

The growth of the bone is indicated in the following table. The otoliths, even of adult shad, are so small that differences of size are not readily noticed by the unaided eye. Microscopic measurements, however, show the differences plainly.

TABLE I.

Growth of male shad and their otoliths; ages based on number of transverse grooves in scales. Fish taken from April to July.

Serial Number	Total length of fish.	Otolith length.	Mean total length of fish.	Mean otolith length.
Age - 1 year and 2 months				
112	14.3 cm.	1.4 mm.	14.3 cm.	1.4 mm.
Age - 3 years				
94	29.5 cm.	3.4 mm.	29.5 cm.	3.4 mm.
Age - 4 years				
2	31.5 cm.	3.5 mm.		
54	35.0 cm.	3.3 mm.	32.2 cm.	3.4 mm.
Age - 5 years				
351	39.0 cm.	3.4 mm.		
292	32.5 cm.	3.4 mm.		
294	34.3 cm.	3.0 mm.		
344	35.0 cm.	4.0 mm.		
352	39.0 cm.	3.8 mm.		
342	32.5 cm.	3.5 mm.	35.1 cm.	3.6 mm.
Age - 6 years				
349	37.5 cm.	3.8 mm.		
336	38.7 cm.	3.8 mm.	38.1 cm.	3.85 mm.
340	38.7 cm.	4.1 mm.		
Age - 7 years				
339	45 cm.	4.0 mm.		
306	46 cm.	4.3 mm.		
317	46 cm.	3.7 mm.		
324	45 cm.	3.9 mm.		
297	47 cm.	4.1 mm.		
300	47.5 cm.	3.9 mm.		
348	46.2 cm.	4.2 mm.		
337	46.7 cm.	4.1 mm.		
341	47.5 cm.	4.1 mm.		
305	48.0 cm.	4.2 mm.		
309	50.0 cm.	4.4 mm.		
313	48.0 cm.	4.7 mm.		
316	50.0 cm.	4.5 mm.		
319	49.0 cm.	4.5 mm.		
322	48.0 cm.	4.2 mm.		
345	42.5 cm.	4.8 mm.		
296	50.0 cm.	4.8 mm.	46.85 cm.	42.0 mm.
Age - 8 years				
320	51.5 cm.	3.9 mm.		
330	46.0 cm.	4.4 mm.		
331	46.0 cm.	4.0 mm.		
293	47.5 cm.	4.5 mm.		
299	49.5 cm.	4.5 mm.		
326	48.0 cm.	4.4 mm.		
338	47.5 cm.	4.8 mm.	47.7 cm.	43.1 mm.
Age - 9 years				
346	46.2 cm.	4.3 mm.		
343	45.0 cm.	5.1 mm.		
334	50.0 cm.	4.8 mm.	46.9 cm.	46.1 mm.

TABLE I (continued)

Growth of female shad and their otoliths—age based on number of transverse grooves in scales. Fish taken from April to July.

Serial Number	Total length of fish.	Otolith length.	Mean total length of fish.	Mean otolith length.
Age - 7 years				
318	51.5 cm.	4.0 mm.		
327	46.0 cm.	4.5 mm.		
328	47.0 cm.	4.1 mm.		
335	47.0 cm.	4.0 mm.		
314	48.0 cm.	4.4 mm.		
325	50.0 cm.	4.2 mm.		
303	50.0 cm.	4.3 mm.		
347	46.2 cm.	4.8 mm.	47.3 cm.	4.24 mm.
Age - 8 years				
302	52.0 cm.	4.6 mm.		
312	52.0 cm.	4.5 mm.		
315	52.0 cm.	4.5 mm.		
321	50.0 cm.	4.4 mm.	51.0 cm.	4.45 mm.
Age - 9 years				
323	51.0 cm.	4.3 mm.		
310	55.0 cm.	5.1 mm.		
329	53.0 cm.	5.2 mm.		
332	48.0 cm.	4.3 mm.	51.5 cm.	46.5 mm.

Table I indicates that the mean length of the otolith in shad of both sexes are in reasonable agreement with the ages as indicated by scale observations. In addition to this agreement between the length of the otolith and age of the fish, there is further evidence in the otoliths that the age estimate based on scale characters as reported by Borodin is correct.

There are at hand specimens of Connecticut River shad varying in age, as estimated by scale study and by actual knowledge of the life of the fish from less than one month to ten years.

This collection of fish contains an uncommon specimen of intermediate size between that of large fingerlings about to enter salt water for the first time and of small adults returning to fresh water to spawn presumably for the first time. The size and characteristics of the otoliths of this fish substantiate the scale method of estimating age. It is known that first year shad taken from fresh water in October and November are usually from 7 to 9 cm. long. The next larger shad available is the one mentioned above. It was taken on June 18th from Long Island Sound not far from the mouth of the Connecticut River. This fish is 14 cm. long. It must be, therefore, if hatched in early

May, one year and nearly two months old. It assuredly cannot be younger. It cannot reasonably be supposed to be two years and two months old. The scales of this fish possess a single annulus and two complete transverse grooves. This is as Borodin claims for a one-year-old shad. The facts concerning this fish furnish a basis for age determination by use of the otolith, for there is now available an "ear stone" of certain length, 1.4 mm. (.85 mm. from nucleus to basal edge), from a fish whose age is reasonably established at one year and nearly two months. This otolith is characterized, moreover, by a single well defined "ring" which appears very close to the margin of the bone. This "ring" is .8 mm. from the nucleus if measured on the basal end of the otolith. This is the first annulus. It should be noted that this otolith is of light color.

The next older fish available is one which was taken from the Salmon River on June 17, 1924. This was a ripe male with standard length of 25.0 cm. Its scales suggest it to be three years old. Its otolith measures 3.4 mm. in length and substantiates this age diagnosis for it is characterized by a central definitely limited light-colored area which measures from its nucleus to basal margin .83 mm. It has been pointed out above that the one year and two months fish possessed an otolith of light color which measured .8 from nucleus to the first annulus. The definite line, therefore, in the otolith of this 25 cm. shad, limiting this central area and appearing at .83 millimeters distance from the nucleus, must be the first annulus. It is significant that in older otoliths the first annulus is always readily distinguishable. Beyond it there are deposited two bands of bone. The first band exterior to the first annulus is a heavier and much darker band whose width on the basal edge measures .29 mm. The edge of this band is definitely lined and represents the second annulus. From the second annulus to the edge of the otolith there is a third band which indicates the growth of the otolith from the end of the second year to the time of catch, June 17, about the date of the third anniversary of its birth. The third year's accretion is also darker in color than the first year's and measures .21 mm. in width. It is of significance that in all older otoliths examined the first annulus is surrounded by three similar bands of dark greyish brown bone, quite different in appearance from the light central region.

The collections made during this investigation contain two male shad whose scales suggest that they are four years old. These were caught in April and May. As these months are included in the shad spawning season these fish must have been taken at about the date of the anniversaries of their birth. Their otoliths, as intimated above, are characterized by the typical first year light-colored central area measuring approximately .8 mm. from the nucleus to the basal edge or first annulus. This central region is surrounded by three concentric dark bands. Of an otolith of one of these specimens taken April 21, 1924, the measurements of the widths of the concentric bands are as follows:

From nucleus to first annulus - .91 mm.

From first to second annulus - .21 mm.

From second to third annulus - .18 mm.

From third to margin of otolith - .19 mm.

These measurements are in satisfactory agreement with measurements made on younger otoliths. Here again it is evident that the annulus is laid down around the anniversary of the birth date of the fish.

It is clear from this discussion that the age of shad up to and including four years as estimated by Borodin's method of halving the number of scale grooves is substantiated by the presence of annual rings in proportional number in the otolith.

For older shad the otolith is no less confirmatory of the scale method of estimating age, although the increasing thickness of the otolith as age advances tends to cloud, to some degree, the earlier annuli. However, the first annulus serves as a useful landmark as does also the fourth. Continued observation and measurements of a large number of otoliths have placed the first and fourth annuli at definite distances from the nucleus. If the measurements are made in the basal direction, these annuli occur at the following distances from the nucleus: first annulus, about 0.8 to 0.9 mm., fourth annulus, about 1.5 to 1.7 mm. The fourth annulus like the first is very plainly indicated in older otoliths. Thus, in an otolith of a shad purporting by scale observation to be five years old (fish taken on July 11, 1924) the fourth annulus is very definitely established at the edge of the three dark bands (second, third and fourth years' accretions). This broad dark band containing three years' deposits stops abruptly near the end of the fourth year. Figure 2 illustrates the point. The fifth year band appears as a narrow lighter stripe on the exterior

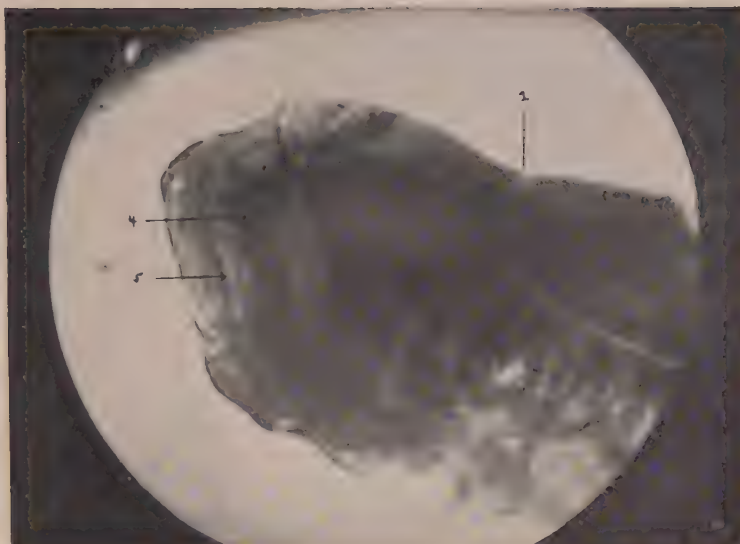


Fig. 2.

Part of otolith of five year old male shad, No. 352, taken from the Salmon River July 11, 1924. Length of fish 39 cm.

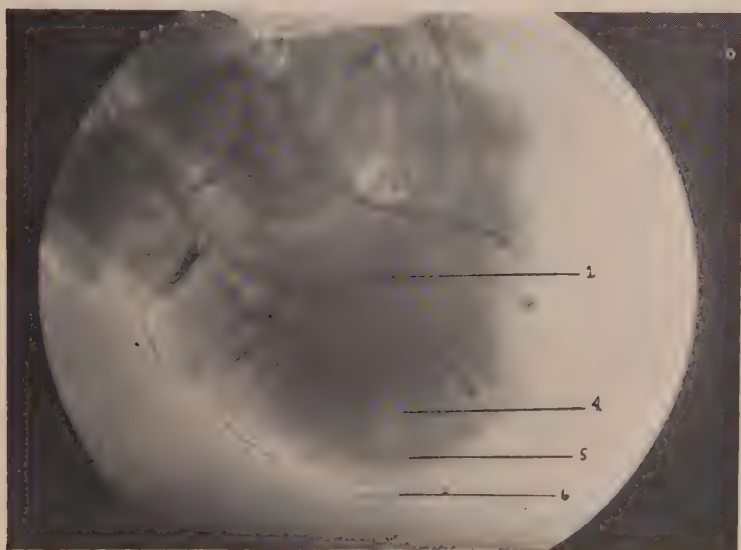


Fig. 3.

Part of otolith of six year old male shad, No. 349, taken from the Salmon River, June 24, 1924. Length of fish 37.5 cm.

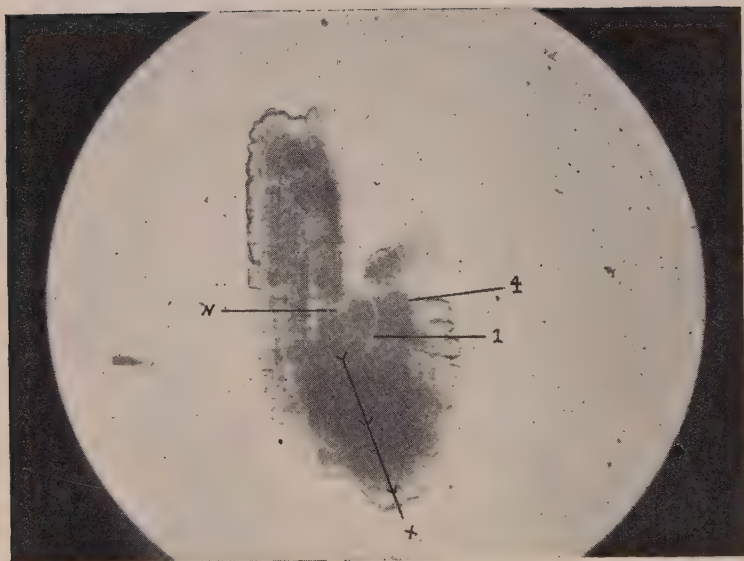


Fig. 4

Entire otolith of nine year old male shad, No. 343, taken from Salmon River, June 24, 1924. Length of fish, 45 cm. First and fourth landmark annuli plainly evident.

of the broad dark band. The accretion occurring since the fifth birthday anniversary date (May 30 to July 11) appears as a fine edge outside the fifth annulus.

An otolith from a shad estimated to be six years old by its scale characteristics shows the one- and four-year landmarks well. The fifth and sixth years' accretions are plainly evident (Fig. 3.).

An otolith of a shad estimated to be seven years old by its scale characteristics shows the first and fourth annuli and three well defined stripes exterior to the fourth. In the microscopic examination of this otolith, the separation of the fifth, sixth and seventh years' deposits stood out more plainly when the microscope was manipulated so that the otolith image was alternately in and partly out of focus. A dark field with direct light sometimes assists in the study of the otolith. If this method is rapidly alternated with examination by transmitted light, the various bands on the edge of the otolith are seen more plainly. Usually the annual accretions are best seen in the regions marked X in Figure 4.

In shad estimated to be eight and nine years old respectively by scale examination, the otoliths give a similar characteristic picture. The first and fourth annuli are easily distinguished at a glance. From the fourth annulus to the margin of the otolith there are interspaced the remaining annuli.

It will be noted that after the fourth annulus the additions to the otolith are not similar to the earlier deposited layers. Nor do the successive layers of the otolith after the fourth extend equally on all sides beyond the previous year's deposit.

It is probable that the characteristics of growth and the color and density of various layers of the otolith are, in a sense, reflections of the conditions of life of the shad. At or near the end of the first year it appears from the otolith that some important change in food or habitat or in both occurs. The second, third, and fourth annual deposits are uniform in color and appearance and are respectively about the same width at the basal part of the otolith (see page 174). These layers, however, are much darker than that included by the first annulus. It seems probable that the central light-colored area ending with the first annulus represents, therefore, the life of the young shad in fresh water. Juvenile shad have been taken from fresh water as late as November. The three dark bands encircling the light-colored area may represent, accordingly, the early life in the sea where growth is fairly regular and where the

temperature of the water and the kind and amount of food do not vary greatly. There is evidently a change in habitat or food abundance, or in the nature of assimilation or utilization of nutritive materials after the fourth year, for there is a marked change in the appearance of the otolith beyond the fourth annulus. This change may be due to the attainment of sexual maturity. It is known that the buck shad* is ripe at the end of the fourth year. On the other hand, however, the youngest ripe roe shad that has been taken in this investigation appears to be seven years old. Probably younger females do not migrate far into fresh water to spawn. It is possible that they may spawn closer to the sea than do the older females and because of this they may be missing from our collections. In any case the otoliths of the shad do not give any indication that the habits of the buck and roe in this respect are different. In both males and females the first and fourth annuli are very prominent landmarks.

It is worthy of note that Borodin has found similar characteristic landmark annuli in the scales of shad. Considering this point he has written "annuli of scales of the first and fourth years are always more distinct and have different appearance from the others." Beginning with the fifth year's accretion the otolith of male or female shows a steady increase in size with quite uniformly early additions and an appreciable change in color and appearance of the successive layers. This is due, it would seem, to a regular succession of events, including life in the sea, the annual ripening of the fish and the spawning migration. Evidently the adult shad migrates to fresh water annually to spawn and then returns to an area in the sea where conditions year after year vary but little.

SUMMARY

The data here presented and the accompanying discussion stand as a reasonable confirmation of Borodin's method of estimating the age of Connecticut River shad. The confirmation is based:

1. On the size and appearance of an otolith of an immature shad whose age has been reasonably established as one year and about two months and whose scales possess a single annulus and two transverse grooves.

*A single ripe three-years old buck shad has been taken from the Salmon River but this appears to be unusual.

2. On the presence in the otolith of this shad of a single definite annulus near the edge of the bone.

3. On the presence of annuli in the otolith of shad representing the annual termination of the limy deposits, their number being in agreement with the age of the fish in years as estimated by Borodin.

4. On the presence in our collections of shad of increasing size possessing a proportionately increasing number of transverse grooves in their scales and possessing otoliths with proportionately increasing size and number of annuli. Shad whose scales and otoliths have been compared in this report are of the following ages: 1. 3, 4, 5, 6, 7, 8, and 9 years.

AGE OF SHAD (*ALOSA SAPIDISSIMA* WILSON) AS DETERMINED BY THE SCALES

BY PROF. N. BORODIN.

The study of shad scales was made during the Winter of 1923-1924 and the Spring of 1924 as a portion of the work of shad investigation, undertaken by the Connecticut State Board of Fisheries.

PREVIOUS WORK.

I could not find in the literature any record of the study of shad scales from the point of view of age determination. Dr. T. D. A. Cockerell, when examining scales of different fishes from the taxonomic point of view, gives a short description of the scales of the shad (Proceedings of the Biological Society of Washington, Vol. XXIII, pp. 61-64, 1910). In his other paper (Smithsonian Misc. Coll. Vol. XVI, P. 2, 1912) there is a drawing of a shad scale, but it was taken probably, from the caudal peduncle and is not typical of shad scales.

There are several works on scales of herring, which belongs to the same family Clupeidae. Knut Dahl¹ and Einar Lea^{2 3} have reported detailed work on the herring scale as a means of determining age, growth and migration of this fish. They have also published a description of methods used by them. A. Nedoshivin and M. Tihiy used scales for the determination of age of the Caspian herrings (*Caspialosa* Berg).⁴

When dealing with herring scales, these authors evidently did not find any difficulties in reading the number of annuli for determination of age. Many thousands of specimens were examined by them and the results are presented in many tables, which accompany the papers. There are also many drawings of scales, but only three photographs.

METHOD APPLIED FOR DETERMINING AGE OF SHAD.

In the case of shad scales difficulties in counting annuli (Fig 1.) arise at once. Some circuli may be confused with the

¹Knut Dahl. The scale of the herring as means of determining age, growth and migration. Rep. on Norwegian Fisheries and Marine Investigation, Vol. II, 1907 p. 6.

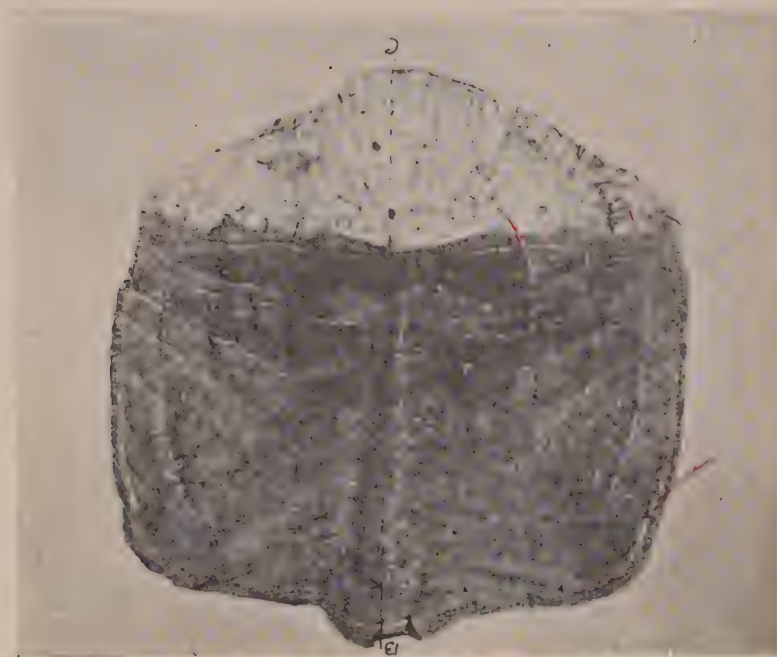
²Einar Lea. On the method used in the herring investigations. Conseil permanent international pour l'exploration de la mer. Publications de Circonstance, 53 (1910).

³Einar Lea. A study of the growth of herring Ibid. 61 (1911) and 66 (1913).

⁴A. Nedoshivin and M. Tihiy. The determination of the age of *Clupionella caspia*. Contributions to the knowledge of Russian Fisheries, Vol. XX. Part 6, 1923. St. Petersburg, (Russian).

Typical shad scale removed from male 5 years old, length 36 cm. B-C, length of scale

Fig. 1.



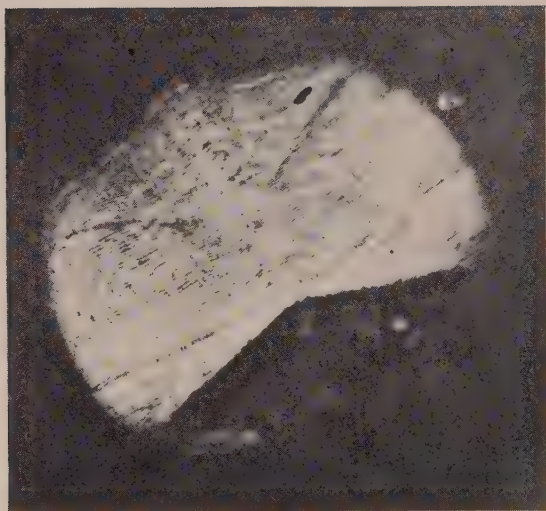


Fig. 3.

Scale of shad fingerling 4 months old showing two incomplete transverse grooves.

annuli and only a few shad scales show annuli clearly. No treatment used in examining scales of other fishes is effective with shad scales: macerating, staining by picrocarmin, decalcification—all were tried but without the desired success. I could not use polarized light because of the lack of equipment. I found after trying various methods that the best one to be applied to the shad scale is the simplest, namely: after soaking the scale in water and cleaning it of glutinous stuff by means of a brush, examine it for reading transverse grooves in water; for reading annuli,—dry it flat on the object slide and examine it dry. Fresh scales are much easier to clean right away, by merely rubbing them between the fingers with cheese cloth.

Being convinced by experience that counting only annuli is not always certain with shad scales, I tried to find some additional marks in order to have a possibility of checking the results and to make corrections. Besides circuli and annuli which are found on all other fish scales, previously examined, there are, on the shad scale, two kinds of other very distinct lines, namely: numerous parallel striae, running transversely and crossing annuli in the central part of the scale at about a right angle, and less numerous and more distinct transverse grooves running in the same way as striae, but always parallel to them and having a different structure.

Striae and transverse grooves are found on the scale of even young shad of a known age of 4 to 5 months. They have at least two grooves on each scale (2 mm. long) of young shad, (Fig. 3). The grooves of larger scales are more numerous and in general, their number is bigger. The larger scales, generally speaking, belong to the shad of larger size.

Comparing the number of circuli on the scales on which observations are clear enough, I found that the number of transverse grooves is always even and, noting that during the first year the shad scale has at least two complete grooves and its annulus is represented by the very edge of the scale—I thought that there is some reason to deduce that each following year there must be one annulus and at least two more grooves; and so it is in reality. The number of complete transverse grooves, divided by two, gives the number of years corresponding to the number of annuli.

I emphasize the word "complete," because if one counts all grooves the number will not correspond to the number of years. They may show in some cases additional months of the next year, but to avoid miscounting and for sim-

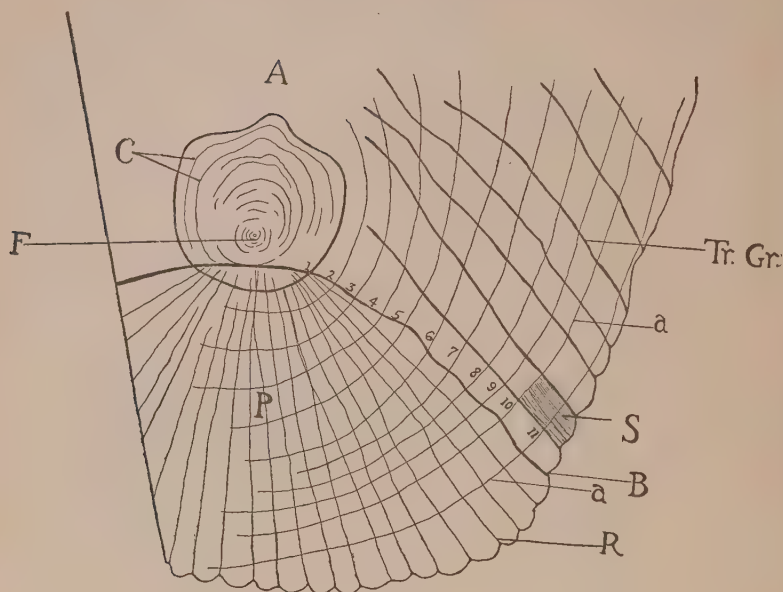


Fig. 2.

Segment of shad scale showing markings used in determining age. A, anterior straited portion; P, posterior part of scale; B, boundary between the anterior and posterior parts; C, circuli; F, focus; a, annuli; R, radius; S, striae; Striae cover entire anterior portion) Tr. Gr., transverse groove.

plicity's sake I neglect them in reading. To illustrate the method used, I refer to the drawing (Fig. 2.) on which all lines and grooves are shown.

To avoid misunderstanding I must say, that when examining shad scales I always count annuli as well as transverse grooves, so that one reading supplements the other. But in cases when annuli are not readable at all, I limit myself by using only transverse grooves.

SOURCES OF SHAD SCALES USED FOR STUDY, ACKNOWLEDGMENTS.

My study of shad scales was begun at Hartford when the season of shad fishing was over (November of 1923). I have had plenty of young shad (fingerlings) and their scales, but not more than a dozen preserved scales taken in the Spring of 1923.

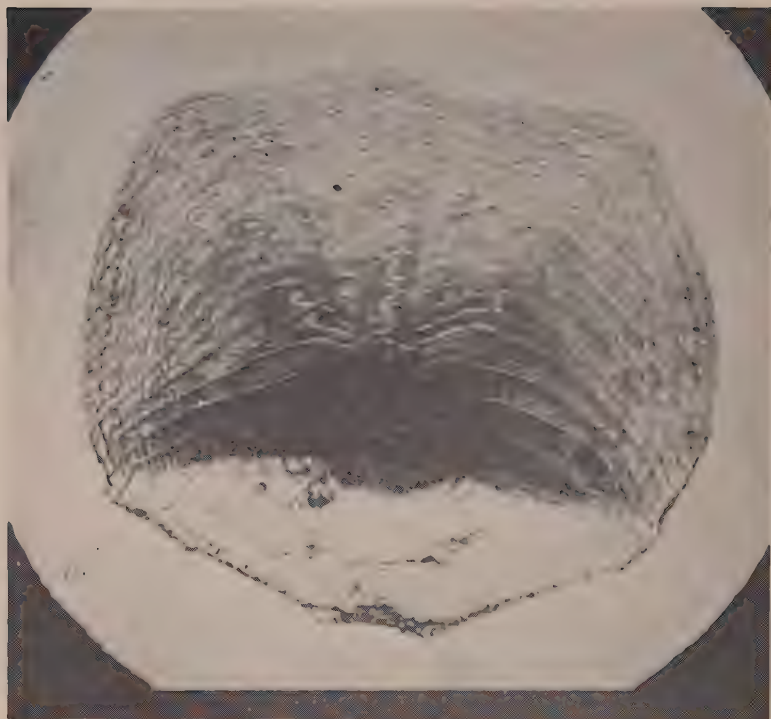


Fig. 4.
Typical shad scale of male 50 cm. long; 9 years old.



Fig. 5
Regenerated scale of shad, female, 54 cm. long.

I take this opportunity to express my thanks to Prof. A. Petrunkevitch of Yale University for his valuable advice and assistance in preparing microphotographs and to Prof. H. A. Swan and R. W. Storrs of Trinity College for loaning me a microtome, etc. I also wish to express my thanks to Mr. A. H. Leim, who shared with me his collection, to Dr. S. Henshaw and Dr. S. Garman of the Cambridge Museum of Comparative Zoology, who permitted me to examine shad at the museum, to Dr. H. W. Fowler of Philadelphia Academy of Natural Sciences and to the U. S. National Museum of Washington in the person of Mr. W. C. Ravenel and Mr. B. J. Bean, who had delivered to me scales of very rare specimens of shad from salt water. Later on I got scales from shad purchased at New York fish markets including shad from the Pacific Coast, frozen; from Florida and from North Carolina. I examined 100 samples of scales, collected by the U. S. Bureau of Fisheries in 1916 taken from different places along the Atlantic coast, and finally 114 samples of shad taken in 1924 from the Connecticut River and Long Island Sound.

EXTERIOR VIEW OF SHAD'S SCALE: DIVERSITY OF FORMS;
SCALES USED FOR DETERMINING AGE.

The accompanying picture gives the best idea of the regular form of the shad scale (Figure 4), but in general the form is very diversified even on one and the same specimen on different portions of the body.

Thus, it is very important for age determination to choose scales correctly and from about the same place for every separate fish examined. I have picked scales from the anterior part of the body at a point about half way between lateral line and pectoral fin. In fact, most of the scales on the body of the shad besides those on the belly, fins or caudal peduncle, are very similar and are what I call regular in shape, though they are a little bit different in size. No irregular scales were used for reading annuli and grooves.

Besides scales of irregular exterior form, i. e., with irregularly shaped edge, scales very often occur with irregular interior structure, as can be seen in Fig. 5. These are regenerated scales, scales which replace the lost ones as the result of some bodily injury. These can not be used for reading annuli or grooves which are all mixed up in a peculiar and complicated net of lines.

INTERIOR STRUCTURE OF SHAD SCALES.

Though I have some cross sections and other preparations made from shad scales and several drawings and microphotographs, I refrain, for the present, from publishing this part of my study which I hope to complete later. However, I wish to state here that transverse grooves running across the scale are really not accumulated striae, as it might be supposed by the analogy with circuli and annuli of salmon scales, but are really grooves on the surface of the scale, and when stained, they fill with stain and are more visible than any other lines. They are not always parallel to the striae and sometimes cross them at acute angles as may be seen in microphotographs (Fig. 6.).

On the other hand annuli are not on the surface of the scale, but are internal structures, that is why they are not so clearly visible as grooves. The annuli are always parallel to the side edges of the scale and in the middle portion of the scale they cross transversal grooves at right or nearly at right angles. (Fig. 6).

All that is said above relates to the anterior striated portion of the scale which is placed in a fish-skin pocket. The smaller sized posterior portion of the scale has no striae. It is transparent and has a frayed margin. There are radii running from the focus. All structures of this portion of the shad scale resemble very much the shell of a scallop. Posterior parts of circuli and annuli can also be seen very often on this portion of the scale (Figs. 1 and 4).

One important point about annuli must be mentioned: annuli of the first and fourth year are always more distinct and have a different appearance from the others. They resemble "spawn marks" of salmon and the fourth annulus, probably, corresponds to the spawn mark, because male shad mature when 4 years old.

CHANGES OF FORM AND SIZE OF SCALE WITH THE
GROWTH OF FISH.

The form of the shad scale undergoes important changes even during the first year. Later on, the form of regular shad scales remains constant, though there are variations in the proportion of the length to the width. By length of the scale is meant the measurement from the front tip of the scale to the apical or posterior edge (line B-C in Fig. 1).

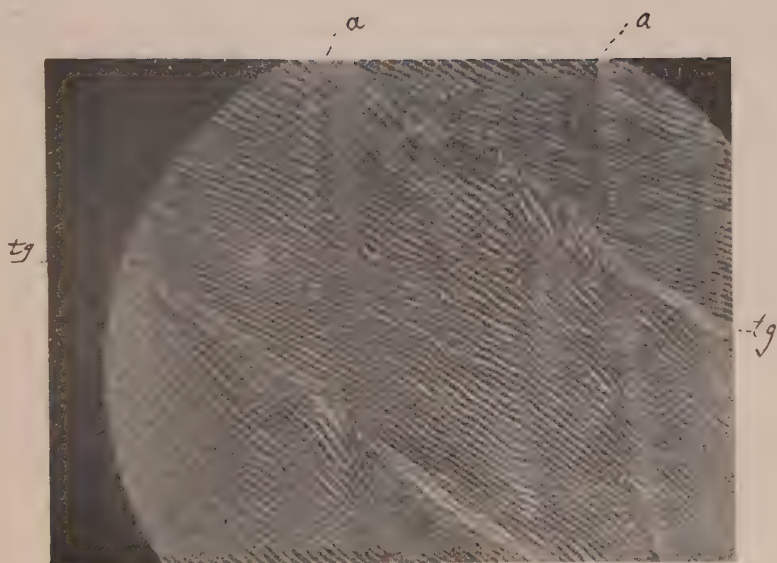


Fig. 6.

Portion of shad scale showing annuli (a) and transverse grooves (tg.) crossing them, x62.

GROUPS OF SHAD ARRANGED BY SIZE AND AGE.

Applying the above described method of determining age of shad by reading annuli and transverse grooves, we can state that the growth of shad, speaking generally, runs as follows:

Groups	Number of specimens examined.	
I	26	Shad of size 5.8–11.3 cm. are in their 1st year
II	4	Those of size 14.5–18 cm. are in their 2nd year
III	7	Those of size 21–29 cm. are in their 3rd year
IV	10	Those of size 30–35 cm. are in their 4th year
V	22	Those of size 36–39 cm. are in their 5th year
VI	22	Those of size 40–43 cm. are in their 5th, 6th and 7th year
VII	43	Those of size 44–48 cm. are in their 6th, 7th and 8th year
VIII	41	Those of size 49–52 cm. are in their 7th, 8th and 9th year
IX	49	Those of size 53–57 cm. are in their 7th, 8th, 9th and 10th year
X	24	Those of size 58–66 cm. are in their 8th, 9th, 10th and 11th year

Total, 250 (26 young, 92 females, 128 males and 4 unclassified).

Specimens of sizes 5.8–11.3 cm. (group I) are summerlings caught in the river, or taken from the retaining pond artificially hatched and reared.

Specimens of sizes 11–29 cm. (groups II and III, age 1–3 years) are very rare and were all caught in salt water. In fact, only two specimens of 14.5 cm. were delivered to me from Long Island Sound; from all other specimens of these groups I had only scales and sizes.

Specimens of groups IV and V are young bucks (males) entering the river. Group VI (size 40–43 cm., age 5, 6 and 7 years) consists also mostly of males (9 females out of 22 specimens).

Group VII (size 44–48, ages 6, 7 and 8) consists also mostly of males (9 females out of 43 specimens).

In group VIII (size 49–52 cm., ages mostly 7 and 8 years) females are more numerous (13 out of 41).

In group IX (size 53–57 cm., ages mostly 8 and 9 years) females are predominant (43 out of 49).

In group X (sizes 58–66 cm., ages 9, 10 and 11 years, there is only one male (58 cm.) out of 24 specimens.

All specimens of the groups IV–X are caught mostly in the rivers, few of them in brackish waters of bays and sounds, near the mouths of rivers.

According to the figures of the foregoing table, supplemented with the data on the time of catch, shad males (bucks) are coming to the rivers after attaining an age of 4 years (few, size 30–35 cm., weight 200–300 grams); most of the males in the Connecticut River during the season of 1924 were 5–7 years old (size 36–49 cm., weight about 450, 670, 1,000 grams, $1\frac{1}{2}$ – $2\frac{1}{4}$ pounds). Males are in

general of smaller size than females (roes) and specimens of males over 53 cm. (weight 1,750 grams) are very rare.

Shad females (roes) entering rivers are 7 and more years old (size 43–66 cm., weight about 1,300, 2,000, 3,000 grams). The largest specimen of roe shad obtained from the Connecticut River region was 61 cm. long, $6\frac{3}{4}$ pounds or 3,060 grams in weight. The smallest was 43 cm. long and weighed 821 grams. Most of the roe shad, caught in the Connecticut River during the season of 1924, were about 2,000 grams or $4\frac{1}{2}$ pounds in weight.

There is no difference in the age of the shad males and females of the same sizes. This statement relates to specimens of groups VII and VIII.

There are still several missing links in the chain of records of growth of the shad females of ages 3–7 years. They are probably living in the ocean, are caught by the fishermen only occasionally and have not yet been examined for age determination.

Scales of the shad, taken from the same part of the body of fish of the same size, are, generally speaking, of the same size. The larger the specimen, the larger are the scales, and vice-versa. The following table shows it very clearly, but the age cannot be determined by the size of scale only.

Length of scale mm.	Length of fish cm.	Length of scale mm.	Length of fish cm.
1.5–3	5.8–10.3	11	35–36
4–5	14–17	12–13	39–46
7–8	18–26	14–14.5	49–50
8–9	29–31	15	52–54
10	33	16–17	54–61
		18–19	59–63

A COMPARATIVE STUDY OF NATURAL AND ARTIFICIAL FOODS OF BROOK TROUT.

BY G. C. EMBODY AND MYRON GORDON

Prerequisite to the laying out of a modern feeding experiment with brook trout, it is well to have a fairly accurate notion as to the character of the food secured in nature. In the case of trout, as with other animals that have been studied, this food is known to consist of certain substances called proteins, carbohydrates, fats, vitamins and mineral matter. If a proper ratio between them is not maintained, it is believed that trout cannot live, grow and reproduce in a normal manner.

In the transactions of this Society for 1918, p. 26, the senior author reported upon some trout feeding experiments with various mixtures of "animal", fish, shrimp, and vegetable meals. Here it was shown that these products could not be used alone and continuously without impairing the health of trout and diminishing the rate of growth. Furthermore, it was found that when about 15 per cent of the food mixture consisted of fresh liver, kidney or melts, normal growth and health were apparently restored. We now believe that the unsatisfactory results were due to a deficiency of vitamins in the dried foods; that although these vitamins may have been present in sufficient quantities in the original undried tissues, they were partly or wholly destroyed in the process of manufacturing the meals. The addition of fresh liver and other meats restored the vitamin balance.

It has been our desire to follow this out more carefully and to determine what vitamins were required by trout and whether these could be supplied from materials other than fresh meat. Preliminary to this work, however, it was thought that we should know something more about the proper ratio of the other food substances namely; the protein, fat, carbohydrate and minerals. It is our purpose in the present paper to throw some light upon this latter subject.

We believe that nature is a good guide towards the determination of what is proper food for trout, because wild trout are almost invariably healthy, except where certain undesirable conditions prevail, and because diseased trout have been known to regain normal health and vigor when placed in natural waters and allowed to forage upon natural food. Therefore we have first tried to put together scattered information obtained by various investigators re-

lating to the natural food organisms secured by brook trout and finally we have tried to arrive at a fairly definite conclusion as to the chemical composition of the average natural ration, particularly with regard to the ratio in which the various food substances occur.

Doctors Needham, Juday and Pearse in their published works, have supplied the greater part of the data upon which the first part of the paper is based. However, various students of the senior author in the course of their regular laboratory work have contributed to the information contained herein.

Needham, 1903, reported upon a study of the food of 25 brook trout taken from Bone Pond, Saranac Inn, New York. He found the following numbers of the various animals:

Midges (Chironomus)	2906
Midges (Corethra)	156
Caddis fly larvae (Trichoptera)	14
Dragon fly nymphs (Aeschna)	2
May fly nymphs (Callibaetis)	7
Water mites (Atax)	8
Water fleas (Daphnidae)	250

Among other "miscellaneous and unimportant" things, he mentions the parts of two terrestrial beetles, a little fresh water mussel and scales of trout.

With the exception of the two beetles all of the animals recorded are distinctly aquatic. A decided preference for midge larvae is indicated. Their cases together with those of the caddis flies were abundant in the pond and the trout were able to obtain them with little effort.

However, midge larvae are not so easily available to trout in some other lakes and streams and in these waters, we find them replaced to a large extent by other animals.

The following tables, I and II, have been derived from the works of Juday, 1907, Pearse, 1915 and from unpublished notes taken by various students already referred to.

TABLE I.

Natural food of brook trout from Juday, Pearse and others.

Values expressed in per cent by volume.

Food organisms	127 specimens from Colorado	16 specimens from New York	18 specimens from Wisconsin	Average of 161 sp.
Fish	1.48	6.50		1.81
Araneida (Spiders)	.80	.70		.70
Hydrachnidae (Watermites) ...	.46		.40	.41
Ephemera (Mayflies)	.54	.60		.48
Plecoptera (Stoneflies)		2.80		.28
Orthoptera (Grasshoppers)	3.80	11.20	3.00	4.44
Hemiptera (Bugs)	.87	2.60	.40	1.38
Neuroptera (Dobsons etc.)	.16			.13
Trichoptera (Caddisflies)	.72	2.20	11.50	2.05
Lepidoptera (Moths)	1.18	8.80		1.81
Diptera (Two-winged flies)	2.00	14.70	6.60	3.77
Chironomus (midge) larvae	3.75		32.40	6.51
Coleoptera (Beetles)	5.40	7.00	3.60	5.27
Hymenoptera (Bees, wasps, ants)	9.15	6.80	.10	7.90
Insect fragments	31.10	1.80		24.68
Crustacea (Crayfish, shrimps etc.)	.07	14.40	36.80	5.54
Mollusca			1.40	.15
Vegetable debris	36.05	.40	.10	28.71
Sand and gravel	2.47			1.95
Unrecognizable		19.10		1.91

TABLE II.

Summary of Table I.

Fish	1.80%
Insects	59.95
Crustacea	5.50
Mollusca	.15
Vegetation and debris	32.60
100.00%	

If we omit the plant material and debris and put the remaining items on a 100% basis, the following table results:

TABLE III.

Fish	2.52%
Insects	88.88
Crustacea	8.23
Mollusca	.27
100.00%	

Only those data referring to trout from 4 to 13 inches long have been used. All of the specimens were captured during the months of July, August and September. Those reported by Juday were taken in Colorado largely from Lake Creek, a tributary to Twin Lakes. Pearse's specimens were taken from a brook about four miles south of Madison, Wisconsin, and the New York specimens were all collected by the senior writer in various streams near Ithaca.

Insects constituted the greater portion of the food, about 59 per cent. Juday states that "with the exception of the small brook trout and the fry, the insect material found consisted chiefly of such forms as fell into the water accidentally". The New York specimens also fed very largely upon terrestrial insects, only about 12 per cent out of 59 having their origin in water.

The hexapod insects found in the New York specimens included the following groups:

Orthoptera

Melanoplus and Eucrotopluplius: grasshoppers.

Acrididae: crickets

Hemiptera.

Pentatomidae: Stinkbugs

Jassidae: leafhoppers

Psyllidae: jumping plant lice

Cercopidae: spittle insects

Veliidae: broad-shouldered water striders

Ephemera: mayflies

Plecoptera: stoneflies

Neuroptera:

Chauliodes: fishflies

Trichoptera: caddisflies

Lepidoptera: moths and butterflies

Notodontidae

Datana

Heterocampa

Eucleidae: slug caterpillar moth

Cymatophoridae

Pseudothyatira

Ennomidae

Noctuidae: owlet moths

Arctiidae: tiger moths

Sphingidae: hawk moths

Diptera: two-winged flies

Empididae: dance flies

Muscinae: house fly and others

Tipulidae: crane flies

Asilidae: robber flies

Therevidae: stiletto-flies

Tachinidae: tachina flies

Bibionidae: march flies

Phoridae: hump back flies

Dolichopodidae: long-legged flies

Coleoptera: beetles

Scarabaeidae

Lachnosterna: June bugs or May beetles

Hydrophilidae: water scavenger beetles

Lampyridae: fire flies

Plateros

Chauliognathus: soldier beetle

Curculionidae: weevils

Byrrhidae: pill beetles

Chrysomelidae: leaf beetles

Coccinelidae: lady beetles

Carabidae: ground beetles

Hymenoptera: bees, ants, etc.

Myrmicidae: ants

Andraenidae: short-tongued bees

Vespina: wasps

Ichneumonidae: ichneumon flies

Braconidae

In Pearse's specimens we find about 47 per cent of the insect food out of a total of 57.6, consisting of true aquatic forms. The largest single group is represented by Chironomid larvae and pupae (32.4%). In this respect the specimens are more like those studied at Needham in Bone Pond, N. Y. Needham reported that the bottom of Bone Pond consisted largely of fine material in which Chironomids were exceedingly abundant. Although those of Pearse were taken in a brook, this brook was evidently a favorable habitat for midge larvae, having many places where the bottom was composed of soft material. Quite different conditions obtain in the streams about Ithaca where the New York specimens were taken and probably also in Lake Creek, Colorado, where Juday secured his specimens. The New York streams were swift with bottoms largely of coarse gravel, not the ideal situation in which to find the more conspicuous forms of midge larvae and this probably accounts for the entire absence of midges in the New York specimens.

In regard to the crustacean element, Juday found only Entomostraca (Daphne and Cyclops) and those were confined to two specimens in Twin Lakes. Apparently no crustacea were found in the Lake Creek specimens. Pearse's specimens contained Caledonia shrimp (Gammarus limnaeus) 35.5 per cent, water sow bugs (Asellus) and terrestrial sow bugs (Porcello) 1.3 per cent. The trout from Ithaca, N. Y., had eaten largely of crayfish (*C. bartonii*) with an occasional shrimp (*Hyaella*). It is rather surprising to note as much as 36 per cent of vegetable substance in Juday's trout. However, he states that "it consisted, for the most part, of pieces of small roots of the

willows growing along the creek and was probably taken by accident."

Fish remains are reported from the larger Colorado and New York trout only. In the former case they consisted entirely of young suckers while in the latter of sculpins (*Cottus*).

It is important to note that brook trout naturally secure a great variety of food organisms. There were some 40 different families of insects belonging to at least 10 orders not to mention 3 families of crustacea and still others including fish, spiders and molluscs. This indicates that trout naturally secure many kinds of proteins and other food principles and consequently it is in argument in favor of using a mixture of various kinds of animal foods in our hatcheries rather than clinging tenaciously to a single item such as heart or liver or melts etc.

It is well to point out the similarity in the results of these investigators who studied trout in three widely separated sections of the country—Colorado, Wisconsin and New York. In the principal item of trout food, the insect material, the percentages are remarkably close 60 per cent, 59 per cent and 58 per cent. It is in the less conspicuous organisms that we find any marked variation, such as the fish and crustacea.

CHEMICAL COMPOSITION OF NATURAL TROUT FOOD.

Chemical analysis of all the organisms mentioned in Table I are not available but from three different sources we have derived enough material perhaps to venture upon a rough estimate of the proportions of protein, carbohydrate, fat, etc., as they appear in the natural trout ration.

The chief source of information has been Birge and Juday, 1922. Here we find analyses of representatives of seven orders of insects, observed in trout stomachs, Table IV, A. By averaging these we obtain what is believed to be a fair value for the insect portion of trout food. Likewise averaging the data from the same source, pertaining to two genera of crustacea, a similarly fair value is obtained for this portion of trout food, Table IV, A₂.

For the molluscan portion (Table IV, A₃), the analysis of the oyster, given by Atwater and Bryant, 1906, has been used. While the oyster does not occur in the list of food organisms, nevertheless it is a mollusk and its composition most likely is not far from the average for fresh water mollusca. Furthermore the molluscan portion of food constitutes but .15 per cent of the whole and whatever error

is introduced must be exceedingly small. Even if this particular item were omitted altogether, the final result would be influenced only to a very slight degree.

In regard to the fish portion (Table IV, A₄) analyses of suckers and sculpins, the two forms eaten by trout, were not available. Thus reference was had to the analysis of fish meal as reported by Henry and Morrison, 1917.

TABLE IV.

Name	Crude Protein	Fat	Nitrogen free extract	Crude fibre	Ash	Authority
A.						
Insect						
Ephemera	55.12	15.43	13.42	5.05	10.98	B. & J.
Sialis	50.44	18.50	22.43	3.77	4.86	B. & J.
Tricoptera	49.56	12.47	23.75	9.11	15.11	B. & J.
Chironomus	46.00	8.00	35.10	5.76	5.14	B. & J.
Gyrinidae	35.88	37.65	10.30	14.47	1.70	B. & J.
Hemiptera	62.12	8.78	10.93	11.78	6.39	B. & J.
Average	49.04	16.52	19.00	8.20	7.24	100 %
A ₂						
Crustacea						
Cambarus	41.25	3.45	10.51	10.42	34.37	B. & J.
Hyaella	46.06	7.60	11.74	6.00	23.60	B. & J.
Average	43.06	5.53	11.12	8.21	31.48	100 %
A ₃						
Mollusca						
Oysters	53.00	14.45	23.50		9.05	100 % A. & B.
A ₄						
Fish						
Fish meal	53.80	13.00			33.20	100 % H. & M.
B.						
Summary						
Insects	49.04	16.52	19.00	8.20	7.24	
Crustacea	43.66	5.53	11.12	8.21	31.48	
Fish	53.80	13.00			33.20	
Mollusca	53.00	14.45	23.50		9.05	
C.						
Averages Taken Proportionally. (See Table III)						
Insects	43.59	14.67	16.90	7.29	6.43 =	88.88 %
Crustacea	3.59	0.45	0.91	0.68	2.60 =	8.23 %
Mollusca	0.20	0.05	0.09		0.03 =	0.37 %
Fish	1.35	0.33			0.84 =	2.52 %
Total	48.73	15.50	17.90	7.97	9.90	100.00 %

In Table IV, C, the composition of the various trout food items are calculated on the basis of the proportions in which they occur in Table III, and finally, by adding the vertical columns, we find the total composition of the average trout ration to be as follows:

	Percent
Crude protein	48.73
Fat	15.00
Carbohydrates	
Nitrogen free extract	17.90
Crude fiber	7.97
Ash	9.90
	100.00

DEFINITION OF TERMS.

Crude protein is the term employed to designate all the nitrogenous compounds of a food. It is found that about 16 per cent of the food protein is nitrogen. Accordingly, the nitrogen found in a given food, by analysis, is multiplied by 6.25 ($100 \div 16 = 6.25$) and is called crude protein.

The function of protein in the diet is one of general body building and repairing of worn tissues. Protein is necessary for growth. Such parts as the skin, muscles, ligaments, tendons and internal organs are almost wholly protein, as is a large part of the nervous system and of the organic portion of the bones. Secondarily, protein may be used as a source of energy.

Fat is a term applied to that of the food which is extracted with ether. It is often referred to as ether extract. Its chief function is to furnish energy for the animal body. When the amount of fat eaten is greater than that required for energy, the excess is stored up in the body.

The ash is that part of the food which remains after burning. It is the mineral matter.

The carbohydrates constitute two groups of food substances: crude fibre and nitrogen free extract.

Crude fibre is a term applied to the organic material which remains undissolved after the food is digested with sulphuric acid and sodium hydroxide. In the animal material, the crude fibre consists of carbohydrates derived chiefly from the chitin of the shells of the crustacea and insects.

The various constituents which have been considered thus far, such as the crude proteins, the fat, the crude fiber, and the ash, do not comprise the whole of the food. This is due to the fact that there are various carbohydrates present (such as sugars) which are not included in these items. It is customary to designate all of the carbohydrates not included in the crude fiber as nitrogen free extract, and the quantity of this extract is determined by difference; that is, the percentages of crude protein, fat, crude fiber and ash are deducted from 100 and the remainder constitutes the percentage of nitrogen free extract. The chief function of the carbohydrates is to furnish energy.

NUTRITIVE RATIO.

By means of the nutritive ratio, the composition of the various foods of trout may be conveniently compared. A nutritive ratio, as defined by Henry and Morrison, 1923, is

that ratio which exists in any given feeding stuff between the digestible crude protein and the combined digestible carbohydrates and fat. Carbohydrates include both the crude fibre and the nitrogen free extract. The nutritive ratio may be expressed by the following fraction:

$$\frac{\text{Digestible Fat} \times 2.25 \text{ (heat equiv. of fat)} + \text{Digestible carbohydrates}}{\text{Digestible Protein.}}$$

For the purpose of this study the nutritive ratio will be defined as the ratio which exists in any given food-stuff between the crude protein and the combined nitrogen free extract and fat. It may be expressed by the following fraction:

$$\frac{\text{Fat} \times 2.25 + \text{Nitrogen Free Extract}}{\text{Crude Protein.}}$$

It will be seen that this definition departs in two ways from the standard definition of Henry and Morrison. In the first place, the word digestible is lacking. There are no working data which would show the digestibility of the various foods when fed to trout. Only in the case of beef heart has the digestibility been determined with any degree of accuracy, (Morgulis '18). Secondly, crude fibre is left out because of its supposed indigestibility. In the animal material the crude fibre is derived from the chitinous covering. Birge and Juday, 1922 say, "The chitinous portion of the crustacean shells passes thru the alimentary canal of fishes without being affected by the digestive processes, so that this part of the plankton, crude fibre, may be regarded as having no food value, and it constitutes a considerable portion of the total crude fibre at times." Insects as well as crustacea possess this chitinous covering and it must constitute the chief element in the crude fibre.

While it might be said that crude fibre has no food value, it cannot be said that it plays an unimportant role in nutrition. The value of a roughage for our domesticated farm animals is well recognized. Even in the case of the pig with its limited means for utilizing crude fibre, the best practice is to feed a definite amount of roughage. And so with the trout, the natural food clearly indicates the presence of a roughage and although this may be entirely indigestible, it probably does aid in the digestion of other materials in the feed.

If we substitute in the above fraction, the values for crude protein, fat and nitrogen free extract found in Table IV,

the nutritive ratio is found to be 1: 1.08, that is 1 part of crude protein to 1.08 parts of fat and nitrogen free extract.

$$\frac{15.5 \times 2.25 + 17.9}{48.73} = 1.08$$

Since the nitrogen free extract is determined by difference it does not tell us of what it is formed. If the nitrogen free extract were rich in sugars, much of it would be digested. If, however, it were in the form of insoluble starches, it might not be digested. Since we have no accurate description of the extract, it is interesting to derive a nutritive ratio by omitting nitrogen free extract—treating it similarly to crude fibre. The fraction would then be:

$$\frac{15.5 \times 2.25}{43.73} = 0.71.$$

that is, 1 part of protein to 0.71 of fat. We may therefore safely say that the nutritive ratio for trout lies between 1: 1.08 and 1: 0.71 with the greater possibility of it being the former.

It is interesting to note here a statement by Dr. Emil Walter (1903) to the effect that the nutritive ratio for the European brown trout lies between .5 and 1.5.

One must not forget that these calculations are based upon the natural food of trout four to thirteen inches long and would not necessarily hold true for smaller trout. Up to the present time not a sufficient number of trout in advanced fry and early fingerling stages, have been studied to give a fair idea of the composition of the natural food.

The nutritive ratio as thus shown is a very narrow one as compared with those already determined for domestic animals. Thus for the horse, it is 1: 8-10; cow 1: 6-7; sheep, 1: 7-8 and swine, 1: 4-5. It is what one might expect, however, from an animal which is almost exclusively a flesh eater.

TABLE V.
Analysis of Fresh Foods from Atwater & Bryant (1906).

Food	Crude Protein	Fat	Nitrogen free Extract	Crude Fibre	Ash	Water	Refuse	Nutritive Ratio
Beef kidney	14.8	24.7			0.9	53.2	5.9	1: 3.8
Beef kidney	13.7	1.9			1.0	63.1	19.9	0.25
Beef lungs	16.4	3.2			1.0	79.7		0.5
Beef liver	20.2	3.1	2.5		1.3	65.6	7.3	0.47
Mutton heart	16.9	12.6			0.9	69.5		1.7
Mutton kidney	16.5	3.2			1.3	78.7		0.4
Mutton lungs	20.2	2.8			1.2	75.9		0.3
Mutton liver	23.1	9.0	5.0		1.7	61.2		1.1
Pork heart	17.1	6.3			1.0	75.6		0.8
Pork kidney	15.5	4.8			1.2	77.8		0.7
Pork lungs	11.9	4.0			0.9	83.3		0.8
Pork liver	21.3	4.5	1.4		1.4	71.4		0.6

TABLE VI.

Analysis of Cereals from Henry & Morrison (1923).

Standard Wheat							
Middlings	17.4	4.9	56.8	6.0	4.4	10.5	4.2
Oatmeal	16.0	6.5	66.1	1.5	2.0	7.9	5.5
Cornmeal	9.8	3.8	72.0	2.3	1.3	11.3	11.1

TABLE VII.

Analysis of Commercial Dried Foods as furnished by Darling & Co., Russia Cement Co., and J. H. Cottman & Co., respectively.

Fishotein	80.5	7.0	0.5	1.5	7.0	0.09
Chickchuck	55.0	2.0		1.0	32.0	0.10
Menhaden						
Fish Meal	57.0	7.0		1.0	31.5	0.28

The nutritive ratios of various artificial foods have been determined and listed in Tables V, VI, and VII. It is seen that there is a great variation in the proportions of the different nutrients, and this is reflected in the nutritive ratio of each food. Of the fresh foods, beef heart has the lowest proportionate protein content and this gives it the wide nutritive ratio of 1: 3.8. Beef kidney has the highest proportionate protein content and its nutritive ratio is very narrow, 1: 0.25. These variations are rather large and should not be overlooked in feeding; it would be erroneous to use these foods interchangeably and expect equal results. Such is also the case with various organs of different animals.

TABLE VIII.

Comparing the Nutritive Ratios of the Same Organs from Different Animals.

	Heart	Kidney	Lungs	Liver
Beef	3.8	0.25	0.50	0.47
Mutton	1.7	0.40	0.40	1.10
Pork	0.8	0.70	0.76	0.55

As seen above, beef heart and mutton heart have a wider nutritive ratio than that of natural food, i. e. 1: 1.08. When fed alone, these foods are fattening. Mutton liver seems to approach natural food most closely. All other fresh foods, listed above, have a narrower ratio than natural food, which means that they have an excessive proportion of protein.

The matter of feeding the correct proportion with respect to other elements of the food is of prime importance. Among the arguments for and against the feeding of protein in excess, the following may be mentioned. Those in favor: first, it makes certain that the animal is receiving a sufficient amount of protein for growth; second, if the protein of the food is rather low in certain essential amino acids, more protein is available to make up this deficiency. Among those against feeding in excess are: first, the protein will be used for energy, but since energy may be derived

from fat and some nitrogen free extract, and these are less expensive than protein, it is an economically poor practice to feed protein in excess; second, when protein is more than sufficient for growth and energy, the excess may be transformed and stored as fat; third, when protein is greatly in excess of normal requirements, the nitrogenous wastes accumulate in the blood, the excretory organs being overburdened, and fatigue results.

The commercial meat and fish meals, Table VII, have extremely narrow nutritive ratios which average 1: 0.1. It is obvious that these dried foods should never be fed alone but should always be fed together with foods which are rich in fats and nitrogen free extract.

MINERAL NUTRITION.

Investigations of comparatively recent date have brought out the importance of minerals in the diets of man and domestic farm animals. It is highly probable that the results of these discoveries may be taken in principle, to apply equally well to the feeding practices in fish culture.

In Table III it is seen that the quantity of mineral matter in the natural food amounts to about 9.9 per cent, calculated on a dry basis. From tables given by Atwater and Bryant, 1906, the mineral matter in heart, liver and lungs has been calculated on the same basis to be as follows:

	Heart	Liver	Lungs
Beef	1.9 %	3.7 %	5.0 %
Sheep	3.0 %	4.4 %	5.0 %
Pork	3.0 %	5.0 %	5.3 %

All of these foods are noticeably deficient in minerals, liver and lungs of pork the least so, while beef heart shows the greatest deficiency. No doubt trout secure some minerals directly from the water in which they live, but this is just as true of wild trout as of those kept in the hatchery ponds and consequently, if wild trout require a certain amount to be taken from the food, one would think that this requirement would obtain for hatchery trout.

Calcium and phosphorus are used in the building of the skeleton and especially important is it that the intake of these two constituents of the food be adequate for use in the case of rapidly growing young trout.

Knauthe, 1901, points out that in the case of carp a deficiency of minerals decreases the capacity of the fish to utilize food. The carp loses its appetite and even if it should not, which is possible for only a short time without sufficient minerals, the utilization of food would be very

low, because much of it passes through the digestive canal without change.

In addition to the above, Knauthe states that there is a gradual increase in the metabolism of protein and at the same time a decrease in fat formation. The carbohydrates are less and less utilized in the formation of body fat and there finally results a loss of weight rather than an increase thereof.

The quantity of mineral matter, however, is not necessarily the most important point to be considered. An analysis of the ash of natural food, Table IX, shows that it contains various kinds of minerals such as calcium, phosphorus, iron, etc. Comparatively recent investigations have shown that certain minerals must be present in the diet and in the case of two at least—calcium and phosphorus,—a more or less definite relation between them must be maintained in order to insure good health.

Undoubtedly iron also functions in a very important way in the body of a fish even though it may be present in but small amount. Probably the greater part of this iron will be found in the hemoglobin of the red blood corpuscles as in the case of mammals where "it is constantly functioning in the general metabolism as a carrier of oxygen upon which all of the oxidative (energy yielding) processes of nutrition depends"—Sherman, 1923.

In the larger mammals improper calcium and phosphorus nutrition tends towards a pathological condition known as rickets. It is not known, however, that trout are susceptible to this disease.

Calcium and phosphorus are also concerned in preserving the proper acid-alkali relations in the body tissues, a necessary requirement for the proper functioning of the organs.

TABLE IX.
Chemical Analysis of the Ash of Some Natural Food Organisms
(From Birge and Juday, 1922.)

Name	Ca O	P ₂ O ₅	Fe ₂ O Al ₂ O ₃	Mg O	Si O ₂	CaO : P ₂ O ₅
Insects						
Zygoptera	0.84	1.50	1.48	0.03	0.54	
Sialis	0.16	1.46	0.46	1.12	0.33	
Chironomus	1.30	2.10		0.46	0.32	
Average	0.77	1.69	0.65	0.54	0.40	
Crustacea						
Cambarus	17.82	2.63	1.56	0.57	0.14	
Hyalella	14.82	2.73	0.75	0.35	0.14	
Average	16.31	2.68	1.16	0.46	0.14	
Summary of Averages						
Insects	0.77	1.69	0.65	0.54	0.40	
Crustacea	16.31	2.68	1.16	0.46	0.14	
Fish	negligible for this count					
Mollusca	negligible for this count					
Summaries Taken Proportionally						
Insects	0.68	1.51	0.58	0.48	0.36	
Crustacea	1.34	0.22	0.10	0.04	0.01	
Total	2.02	1.73	0.68	0.52	0.37	1 : 0.86

TABLE X.
Chemical Analysis of the Ash (100 parts) of the Meat of Animals
(From Wolff, 1871.)

	CaO	P ₂ O ₅	Fe ₂ O ₃	K ₂ O	Na ₂ O	Cl	
Ox	1.3	39.5		37.0	14.5	5.0	
Calf	1.9	39.9		25.0	25.6	4.6	
Pig	7.5	41.4	0.4	37.3	04.5	0.6	
Average	3.6	40.4	0.1	33.1	14.9	3.4	1 : 11.22

Birge and Juday, 1922, included in their tables analyses of the ash of some of the natural food organisms eaten by trout, (Table IX). Unfortunately we do not have similar analyses of the ash of liver, heart and lungs. It is not possible therefore to make close comparisons. However, Wolff in 1871 gave tables showing the composition of the ash in the meat of various domestic animals (Table X). We must presume that this does not differ very greatly from what one might expect to find in liver, heart, etc. The values are on a different basis from those in the table of Birge and Juday and while it is not possible to weigh the absolute values of each, comparison of the ratio of calcium to phosphorus is possible and significant.

The calcium phosphorus ratio of natural food as here calculated is 1 : 0.85.

$$\frac{\text{CaO}}{\text{P}_2\text{O}_5} = \frac{1}{0.85} \text{ or } 1 : 0.85$$

For the meat average ratio computed by a similar method is 1 : 11.22.

If the calcium-phosphorus ratio has any significance in the trout ration, and we assume that the natural food is perfectly balanced in this respect, then the deficiency in the calcium content of the fresh meat is large enough to merit serious attention, particularly so, because it is a customary practice in many hatcheries to feed these fresh meats exclusively.

In conclusion it is well to recall that the aim of the trout culturist is to produce as rapid a growth as is consistent with good health. He has little difficulty in producing the rapid growth with the three foods—heart, liver or melts—but often at the expense of normal health, vigor and reproductive capacity. Serious losses are too often experienced and eggs and melt of inferior quality are too often produced. The assumption that these ills are due directly to the quality of the food, is not always warranted. In many instances, however, it is possible that an improperly balanced ration has been directly the cause.

A food somewhat deficient in one or more nutrients might not cause serious consequences during a comparatively short period but when continued over a longer period, the cumu-

lative effects eventually show themselves, often as a diminished resistance to certain diseases. Some of these may affect the normal functioning of the reproductive organs resulting in inferior spawn.

Whether the differences between natural and artificial foods pointed out in this paper are large enough to account for many of the ills besetting trout culturists, cannot be definitely asserted. It is likely, however, that they may be contributory causes and it would therefore seem worthwhile to test experimentally certain artificial rations conforming more closely with those furnished by nature.

It was with this purpose in mind that the writers brought together the information contained in this paper.

SUMMARY

1. It is assumed that the proportions in which nutrients occur in the natural ration of brook trout are the most desirable in the long run and that in this respect the artificial ration should approximate as closely as possible the natural ration.
2. The brook trout naturally consumes a great variety of food organisms thereby securing many kinds of proteins and other food principles. This fact would constitute an argument in favor of using a mixture of various kinds of food in the hatchery rather than feeding any one animal organ such as liver, heart or melts, to the exclusion of other food products.
3. An approximate value for the nutritive ratio of natural food appears to be 1 : 1.1. That of fresh meat organs varies from 1 : 3.4 in the case of beef heart to 1 : 0.25 for beef kidney.

The dried animal meals have extremely narrow ratios. The average value approximates 1 : 0.10.

No single food seems to be complete in all requirements.

4. Natural food clearly indicates the presence of a roughage in the form of crude fiber.
5. Natural food must be rich in vitamins. To a certain extent this may be said of certain fresh meat products. The dried foods are deficient in these essential substances but may be used in the hatchery, if combined with fresh foods.
6. Minerals appear to constitute about 9.9 per cent of the dry matter in natural food. The artificial foods commonly used in hatcheries appear to be deficient in this respect.

7. Natural food shows a narrow calcium-phosphorus ratio having about one part of calcium oxide to nine-tenths part of phosphorus acid. Fresh meat products are deficient in lime and too rich in phosphoric acid, having approximately one part of calcium oxide to twelve parts of phosphoric acid.
8. It is believed that improperly balanced rations have contributed indirectly at least to certain abnormal losses in the trout hatchery and that the use of a ration more closely resembling that provided by nature, may tend to prevent many of these ills.

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APPENDIX

American Fisheries Society

Organized 1870

CERTIFICATE OF INCORPORATION

We, the undersigned, persons of full age and citizenship of the United States, and a majority being citizens of the District of Columbia, pursuant to and in conformity with sections 599 to 603, inclusive, of the Code of Law for the District of Columbia, enacted March 3, 1901, as amended by the acts approved January 31 and June 30, 1902, hereby associate ourselves together as a society or body corporate and certify in writing:

1. That the name of the Society is the American Fisheries Society.
2. That the term for which it is organized is nine hundred and ninety-nine years.

3. That its particular business and objects are to promote the cause of fish culture; to gather and diffuse information bearing upon its practical success, and upon all matters relating to the fisheries; to unite and encourage all interests of fish culture and the fisheries; and to treat all questions of a scientific and economic character regarding fish; with power:

(a) To acquire, hold and convey real estate and other property, and to establish general and special funds.

(b) To hold meetings.

(c) To publish and distribute documents.

(d) To conduct lectures.

(e) To conduct, endow, or assist investigation in any department of fishery and fish-culture science.

(f) To acquire and maintain a library.

(g) And, in general, to transact any business pertinent to a learned society.

4. That the affairs, funds and property of the corporation shall be in general charge of a council, consisting of the officers and the executive committee, the number of whose members for the first year shall be seventeen, all of whom shall be chosen from among the members of the Society.

Witness our hands and seals this 16th day of December, 1910.

SEYMOUR BOWER (Seal)

THEODORE GILL (Seal)

WILLIAM E. MEEHAN (Seal)

THEODORE S. PALMER (Seal)

BERTRAND H. ROBERTS (Seal)

HUGH M. SMITH (Seal)

RICHARD SYLVESTER (Seal)

Recorded April 16, 1911.

CONSTITUTION

(As amended to date)

ARTICLE I

NAME AND OBJECT

The name of this Society shall be American Fisheries Society. Its object shall be to promote the cause of fish culture; to gather and diffuse information bearing upon its practical success, and upon all matters relating to the fisheries; the uniting and encouraging of all interests of fish culture and the fisheries, and the treatment of all questions regarding fish, of a scientific and economic character.

ARTICLE II

MEMBERSHIP

Active Members.—Any person may upon a two-thirds vote and the payment of three dollars, become a member of this Society. In case members do not pay their fees, which shall be three dollars per year after first year, and are delinquent for two years, they shall be notified by the Treasurer, and if the amount due is not paid within a month thereafter, they shall be, without further notice, dropped from the roll of membership.

Any sporting or fishing club, society, firm or corporation, upon two-thirds vote and the payment of an annual fee of five dollars, may become a member of this Society and be entitled to all its publications. Libraries shall be admitted to membership at three dollars a year.

Any state board or commission may, upon the payment of an annual fee of ten dollars, become a member of this Society and be entitled to all of its publications.

Life Members.—Any person shall, upon a two-thirds vote and the payment of fifty dollars, become a life member of this Society, and shall thereafter be exempt from all annual dues.

Patrons.—Any person, society, club, firm, or corporation, on approval by the Executive Committee and on payment of fifty dollars, may become a patron of this Society with all the privileges of a life member, and then shall be listed as such in all published lists of the Society. The money thus received shall become part of the permanent funds of the Society and the interest alone be used as the Society shall designate.

Honorary and Corresponding Members.—Any person can be made an honorary or corresponding member upon a two-thirds vote of the members present at any regular meeting.

The President (by name) of the United States and the Governors (by name) of the several states shall be honorary members of the Society.

Election of Members Between Annual Meetings.—The President, Recording Secretary, and Treasurer of the Society are hereby authorized, during the time intervening between annual meetings, to act on all individual applications for membership in the Society, a majority vote of the committee to elect or reject such applications as may be duly made.

ARTICLE III

SECTIONS

On presentation of a formal written petition signed by one hundred or more members, the Executive Committee of the American Fisheries Society may approve the formation in any region of a Section of the American Fisheries Society to be known as the _____ Section.

Such a Section may organize by electing its own officers, and by adopting such rules as are not in conflict with the Constitution and By-Laws of the American Fisheries Society.

It may hold meetings and otherwise advance the general interests of the Society, except that the time and place of its annual meeting must receive the approval of the Executive Committee of the American Fisheries Society, and that without specific vote of the American Fisheries Society, the Section shall not commit itself to any expression of public policy on fishing matters.

It may further incur indebtedness to an amount necessary for the conduct of its work not to exceed one-half of the sum received in annual dues from members of said Section.

Such bills duly approved by the Chairman and Recorder of the Section shall be paid on presentation to the Treasurer of the American Fisheries Society.

ARTICLE IV

OFFICERS

The officers of this Society shall be a president and a vice-president, who shall be ineligible for election to the same office until a year after the expiration of their term; an executive secretary, a recording secretary, a treasurer, and an executive committee of seven, which, with the officers before named, shall form a council and transact such business as may be necessary when the Society is not in session—four to constitute a quorum.

In addition to the officers above named there shall be elected annually five vice-presidents who shall be in charge of the following five divisions or sections:

1. Fish Culture.
2. Commercial Fishing.
3. Aquatic biology and physics.
4. Angling.
5. Protection and Legislation.

Vice-presidents of sections may be called upon by the President to present reports of the work of their sections, or they may voluntarily present such reports when material of particular value can be offered by a given division.

ARTICLE V

MEETINGS

The regular meeting of the Society shall be held once a year, the time and place being decided upon at the previous meeting, or, in default of such action, by the executive committee.

ARTICLE VI

ORDER OF BUSINESS

1. Call to order by president.
2. Roll call of members.
3. Applications for membership.
4. Reports of officers.
 - a. President.
 - b. Secretary.
 - c. Treasurer.
 - d. Vice-presidents of Divisions.
 - e. Standing Committees.
5. Committees appointed by the President.
 - a. Committee of five on nomination of officers for ensuing year.
 - b. Committee of three on time and place of next meeting.
 - c. Auditing committee of three.
 - d. Committee of three on program.
 - e. Committee of three on publication.
 - f. Committee of three on publicity.
6. Reading of papers and discussions of same.
(*Note*—In the reading of papers preference shall be given to the members present).
7. Miscellaneous business.
8. Adjournment.

ARTICLE VII

CHANGING THE CONSTITUTION

The Constitution of the Society may be amended, altered or repealed by a two-thirds vote of the members present at any regular meeting, provided at least fifteen members are present at said regular meeting.

American Fisheries Society.

Nov. 21, 1924.

ACTIVE MEMBERS

- '21 Abrams, Milton 560 Brooke Ave., New York City, N. Y.
'23 Acklen, Col. Joseph H. Nashville, Tenn.
'16 Adams, Prof. Charles C. New York State College of Forestry,
Syracuse, N. Y.
'13 Adams, William C. Division of Fisheries & Game, State House,
Boston, Mass.
'18, '23 Ainsworth, Seth M. U. S. Bureau of Fisheries, Charlevoix, Mich.
'20 Albert, W. E. State Fish & Game Warden, Des Moines, Iowa.
'98 Alexander, George L. Grayling, Mich.
'23 Amsler, Guy Department of Fish & Game, Little Rock, Ark.
'24 Anderson, Anders Shoshone Falls, Jerome, Idaho.
'08 Anderson, August J. Box 704, Marquette, Mich.
'14 Anderson, T. T. 4241 Folsom Avenue, St. Louis, Mo.
'24 Annin, Harry K. Spring Street, Caledonia, N. Y.
'14 Annin, Howard Caledonia, N. Y.
'78 Annin, James Caledonia, N. Y.
'21 Armstrong, Ronald Kennedy Bellister Castle, Haltwhistle, Northum-
berland, England.
'22 Arnold, M. Dewey Bemus Point, N. Y.
'10 Augur, W. A. 33 Fulton Street, New York City, N. Y.
'24 Austin, Herbert 102 North St., Boston, Mass.
'06 Avery, Carlos 2205 South Fremont Ave., Minneapolis, Minn.
'01 Babcock, John P. Provincial Fisheries Department, Victoria, B. C.,
Canada.
'12 Babcock, William H. 140 South Dearborn St., Chicago, Ill.
'18 Bailey, Arthur T. R. F. D. 1, Nashua, N. H.
'23 Baird, John Director, Department of Conservation, Lansing, Mich.
'15 Balch, Howard K. 158 West Austin Ave., Chicago, Ill.
'01 Baldwin, O. N. U. S. Bureau of Fisheries, Saratoga, Wyo.
'98 Ball, E. M. U. S. Bureau of Fisheries, Washington, D. C.
'10 Ballard, Thurston 912 East Broadway, Louisville, Ky.
'23 Bangham, Ralph V. Wooster College, Wooster, Ohio
'16 Barber, William E. Conservation Commission, Madison, Wis.
'20 Barbour, F. K. 96 Franklin St., New York City, N. Y.
'05 Barbour, Prof. Thomas Museum of Comparative Zoology, Cam-
bridge, Mass.
'17, '24 Barney, Raymond L. Middlebury College, Middlebury, Vt.
'10 Barron, James T. Thlinket Packing Corporation, 1210 Yeon Bldg.,
Portland, Ore.
'23 Baskett, Cecil M. 925 Syndicate Trust Bldg., St. Louis, Mo.
'12 Bauer, A. 2500 South Dearborn St., Chicago, Ill.
'20 Baxter, A. C. Ohio Fish & Game Division, Columbus, Ohio.
'22 Bayne, Bliss Game & Fish Department, Capitol Bldg., Cheyenne,
'24 Beakbane, Lionel R. F. D. 2, Gansevoort, N. Y.
Wyoming.
'23 Beard, Harry R. U. S. Fisheries Laboratory, San Pedro, Cal.
'00 Beeman, Henry W. New Preston, Conn.
'21 Bell, William G. 512 Munsey Bldg., Baltimore, Md.
'18 Bellisle, J. A. Inspector General of Fisheries & Game, Quebec,
Canada.
'80 Belmont, Perry 1618 New Hampshire Ave., Washington, D. C.
'20 Bennett, L. H. U. S. Bureau of Fisheries, Washington, D. C.

- '13 Berg, George Indiana Fish Commission, Indianapolis, Ind.
- '06 Berkhou, Jerry R. Torresdale Fish Hatchery, Holmesburg, Philadelphia, Penn.
- '19 Bernard, Gus Bernard Fish Company, Atchafalaya, La.
- '21 Bernier, Dr. J. E. No. 5 D'Auteil St., Quebec, Canada.
- '23 Berwick, Dudley Eunice, La.
- '24 Bitzer, Ralph Montague, Mass.
- '13 Blackford, Dr. Charles Minor Staunton, Va. (Deceased).
- '24 Bobleter, J. W. Supt., Yellowstone Hatchery, Emigrant, Mont.
- '23 Bolstad, Sidney L. Aquarium, Lincoln Park Zoo, Chicago, Ill.
- '14 Bolton, C. C. 1550 Hanna Bldg., Cleveland, Ohio.
- '20 Bonner, Albert E. Coopersville, Mich.
- '02 Booth, DeWitt C. U. S. Bureau of Fisheries, Spearfish, S. D.
- '14 Bordenkecher, William R. R. 19, Haughville Station, Indianapolis, Ind.
- '20 Bothwell, David Anderson Lake Hatchery, Kildonan P. O., V. I., British Columbia, Canada.
- '23 Bourland, Dubart E. U. S. Bureau of Fisheries, Tupelo, Miss.
- '24 Bower, Harold S. Department of Conservation, Lansing, Mich.
- '00 Bower, Ward T. U. S. Bureau of Fisheries, Washington, D. C.
- '99 Bowers, George M. Martinsburg, West Virginia.
- '20 Breder, C. M. Jr., New York Aquarium, New York City, N. Y.
- '16 Brown, Dell U. S. Bureau of Fisheries, Mammoth Springs, Ark.
- '14 Brown, Ernest Clive Box 107, Station G., New York City, N. Y.
- '04 Brown, G. W. N. U. S. Bureau of Fisheries, Orangeburg, S. C.
- '23 Brunson, J. H. Louisville, Nebraska.
- '10 Bryan, Prof. William Alanson Director, Los Angeles Museum, Exposition Park, Los Angeles, Cal.
- '18 Buckstaff, George A. 1101-1501 South Main St., Oshkosh, Wis.
- '20 Buller, C. R. Pleasant Mount, Wayne County, Penn.
- '12 Buller, G. W. Pleasant Mount, Wayne County, Penn.
- '19 Bullock, Charles A. U. S. Bureau of Fisheries, Bullochville, Ga.
- '17 Burkhart, Joe Big Rock Creek Trout Club, St. Croix Falls, Wis.
- '07 Burnham, Charles W. U. S. Bureau of Fisheries, Louisville, Ky.
- '20 Buschmann, L. C. Franklin Packing Co., 3102 Smith Bldg., Seattle, Wash.
- '17, '22 Canfield, H. L. U. S. Fisheries Station, Homer, Minn.
- '16 Casler, William A. U. S. Bureau of Fisheries, Washington, D. C.
- '23 Catt, James District Inspector of Hatcheries, R. R. 1., St. John, New Brunswick, Canada.
- '07 Catte, Eugene Catte Fish Hatchery, Langdon, Kansas.
- '18 Chamberlain, Thomas Knight U. S. Fisheries Station, Fairport, Iowa.
- '17 Chambers, E. T. D. Department of Colonization, Mines & Fisheries, Quebec, Canada.
- '19 Chidester, Prof. F. E. West Virginia University, Morgantown, West Virginia.
- '18 Christoffers, H. J. U. S. Fisheries Service, 1217 L. C. Smith Bldg., Seattle, Wash.
- '20 Clapp, Alva Atchison, Kansas.
- '11 Clark, H. Walton Steinhart Aquarium, Golden Gate Park, San Francisco, Cal.
- '23 Claybaug, D. K. Coleman Lake Club, Goodman, Wis.
- '21 Clemens, Dr. Wilbert A. Pacific Biological Station, Nanaimo, British Columbia, Canada.
- '00 Cobb, Eben W. Cedar Island Lodge, Brule, Douglas Co., Wis.
- '04 Cobb, John N. College of Fisheries, Univ. of Washington, Seattle, Wash.

- '04 Coker, Dr. Robert E. Univ. of North Carolina, Chapel Hill, N. C.
'13 Coles, Russell J. Danville, Va.
'19 Commerford, William Milebrook Hatchery, R. F. D. 6, Boonville, N. Y.
'22 Cook, Frank Albany County Hatchery, Box 605, Laramie, Wyo.
'17 Cook, Ward A. U. S. Bureau of Fisheries, Duluth, Minn.
'24 Coolidge, Charles A. 122 Ames Building, Boston, Mass.
'21 Corson, Alan 127 City Hall, Philadelphia, Penn.
'24 Corson, R. H. 25 Tonnele Ave., Jersey City, N. J.
'18 Coykendall, Edward 22 Ferry St., Kingston, N. Y.
'21 Craig, Samuel 398 Van Norman St., Port Arthur, Ontario, Canada.
'13 Crandall, A. J. Ashaway Line & Twine Co., Ashaway, R. I.
'11 Crasser, Hugo U. S. Bureau of Fisheries, La Crosse, Wis.
'20 Crawford, D. R. College of Fisheries, Seattle, Wash.
'20 Crie, H. D. Dea & Shore Fisheries Commission, Rockland, Me.
'08 Culler, C. F. U. S. Bureau of Fisheries, Homer, Minn.
'23 Curtis, Brian C. 125 East 57th St., New York City, N. Y.
'12 Danglede, Ernest Vevay, Indiana.
'06 Davies, David U. S. Fisheries Station, Put-in-Bay, Ohio.
'23 Davis, Dr. H. S. U. S. Bureau of Fisheries, Washington, D. C.
'91, '10 Dean, Prof. Bashford Columbia Univ. New York City, N. Y.
'01 Dean, Herbert D. U. S. Bureau of Fisheries, Charlevoix, Mich.
'24 Dence, Welford A. New York State College of Forestry, Syracuse, N. Y.
'19 Denmead, Talbott 2830 St. Paul St., Baltimore, Md.
'23 Dennig, Louis E. 3817 Choteau, St. Louis, Mo.
'05 De Puy, Henry F. The Sycamores Farm, Easton, Md. Died 10-14-'24.
'08 Detweiler, John Y. Florida Fish Commission, New Smyrna, Fla.
'24 Dickinson, William E. Public Museum, Milwaukee, Wis.
'12, '23 Dilg, Will H. 538 Lake Shore Drive, Chicago, Ill.
'23 Dillon, Horace State Fish Hatchery, Story, Wyo.
'14 Dimick, F. F. Boston Fish Bureau, Fish Pier, Boston, Mass.
'99 Dinsmore, A. H. U. S. Bureau of Fisheries, St. Johnsbury, Vt.
'20 Dolan, George A. Fish Commission, Westerly, R. I.
'99 Downing, S. W. 22 Walnut Street, Norwalk, Ohio.
'09 Doyle, Henry 101 Winch Bldg., Vancouver, B. C., Canada.
'23 Doze, J. B. State Fish Hatchery, Pratt, Kansas.
'20 Dryfoos, Leon 508 State St., Erie, Penn.
'23 Duncan, Charles W. U. S. Bureau of Fisheries, Tupelo, Miss.
'00 Dunlap, Irving H. U. S. Bureau of Fisheries, Washington, D. C.
'24 Earle, Swepson Conservation Commission, Baltimore, Md.
'23 Edmondson, Claude L. U. S. Bureau of Fisheries, Neosho, Mo.
'13 Embody, Dr. George C. Triphammer Road, Ithaca, N. Y.
'21 Emerich, Walter G. R. F. D. 1, Watervliet, N. Y.
'23 Engelhardt, Fred U. S. Bureau of Fisheries, Washington, D. C.
'17 Erickson, C. J. P. O. Box 1446, Boston 2, Mass.
'20 Evans, H. R. Cultus Lake Hatchery, Vedder Crossing Post Office, British Columbia, Canada.
'06 Evans, Lieut.-Col. Kelly Metropolitan Club, New York City, N. Y.
'04 Evermann, J. W. Supervisor of Public Utilities, Dallas, Texas.
'24 Fabyon, Francis H. 72 Franklin St., Boston, Mass.
'18 Fearnow, E. C. U. S. Bureau of Fisheries, Washington, D. C.
'23 Feusted, John G. U. S. Fisheries Station, Homer, Minn.
'20 Fiedler, Reginald H. 310 East 51st St., Seattle, Wash.
'07 Field, Dr. George W. Sharon, Mass.
'12 Finley, W. L. Jennings Lodge, Clackamas Co., Ore.
'04 Fisher, John F. Black Rock Trout Hatchery, Chapinville, Conn.
'20 Fleming, John H. Columbia City, Indiana.
'04 Follet, Richard E. 2134 Dime Bank Bldg., Detroit, Mich.

- '14 Forsyth, Robert 1157 The Rookery, Chicago, Ill.
- '10 Foster, Frederick J. U. S. Bureau of Fisheries, Neosho, Mo.
- '16 Found, William A. Ass't Deputy Minister of Fisheries, Ottawa, Canada.
- '24 Frantz, Horace G. 14 Alsace Way, Colorado Springs, Col.
- '22 Frazer, Dr. C. McLean University of British Columbia, Vancouver, Canada.
- '18 French, Albert International Agri. Corporation, 61 Broadway, New York City, N. Y.
- '18 Fridenberg, Robert 22 West 56th St., New York City, N. Y.
- '23 Furrow, Dr. Charles A. 204 Atlas Life Bldg., Tulsa, Okla.
- '24 Gale, R. G. State Fish Hatchery, French River, Minn.
- '21 Gantenbein, D. Diamond Bluff, Wis.
- '22 Gantenbein, U. Carver New Albin, Iowa.
- '18 Garnsey, Leigh Box 653 Redlands, Cal.
- '13 Gerry, Robert L. Box 1020, City Hall Station, New York City, N. Y.
- '05 Gibbs, Charles E. U. S. Bureau of Fisheries, East Orland, Me.
- '23 Gordon, Myron Cornell Fish Hatchery, Roberts Hall, Ithaca, N. Y.
- '20 Gould, Dr. Edwin W. Sea & Shore Fisheries Commission, 24 School St., Rockland, Me.
- '24 Gould, James F. State Game & Fish Commission, St. Paul, Minn.
- '13 Graham, E. A. Berkeley Hills Trout Farm, Berkeley, Taunton, R. F. D. Mass.
- '03 Gray, George M. Marine Biological Laboratory, Woods Hole, Mass.
- '19 Gray, Stedman H. 2511 West Second Ave., Seattle, Wash.
- '21 Green, John E. Carlton Minn.
- '13 Guerin, Theophile Lock Drawer 1009, Woonsocket, R. I.
- '23 Gullatt, C. H. Union City, Ga.
- '15 Gunckel, Will H. 338 Summit St., Toledo, Ohio.
- '78, '19 Haley, Caleb 14 Fulton Market, New York City, N. Y.
- '24 Hallowell, F. W. 252 Summer St., Boston, Mass.
- '21 Hamberger, Hon. John 16 East 8th St., Erie, Penn.
- '06 Hankinson, Prof. T. L. 96 Oakwood Ave., Ypsilanti, Mich.
- '10 Hansen, Ferdinand 65 Beach St., New York City, N. Y.
- '95 Hansen, G. Troutmere Hatchery, Osceola, Wis.
- '24 Hard, Anson W. Sayville, Long Island, N. Y.
- '19 Hare, Frank E. U. S. Bureau of Fisheries, Manchester, Iowa.
- '17 Harriman, W. A. 39 Broadway, New York City, N. Y.
- '20 Harrison, C. W. Dominion Gov't. Fisheries Office, Molson's Bank Bldg., Vancouver, Canada.
- '03 Harron, L. G. U. S. Bureau of Fisheries, Washington, D. C.
- '22 Hart, Max D. Department of Game & Inland Fisheries, Library Bldg., Richmond, Va.
- '06 Hartmann, Phil. Erie, Pa.
- '22 Harukawa, Dr. Chukichi Ohara Institute for Agricultural Research, Kurashiki, Okayama, Japan.
- '23 Haut, Charles 1533 North Wills St., Chicago, Ill.
- '18 Hawks, S. B. State Fish Hatchery, Bennington, Vt.
- '04 Hay, Prof. W. P. Kensington, Md.
- '04 Hayford, Charles O. State Fish Hatchery, Hackettstown, N. J.
- '24 Hazard, Rowland 43 Exchange Place, New York City, N. Y.
- '08 Hemingway, E. D. 828 North Hancock St., Philadelphia, Penn.
- '84 Henshall, Dr. James A. 813 Dayton St., Cincinnati, Ohio.
- '10 Herrick, Prof. Francis Hobart Western Reserve University, Cleveland, Ohio.
- '23 Heslen, Herman O. Jr., U. S. Bureau of Fisheries, Fairport, Iowa.
- '20 Heuchele, G. L. U. S. Bureau of Fisheries, Put-in-Bay, Ohio.
- '13 Higgins, Alfred S. 142 Atlantic Ave., Boston, Mass.

- ,15 Hildebrand, Samuel F. U. S. Fisheries Laboratory, Beaufort, N. C.
- '08 Hinrichs, Henry, Jr. Booth Fisheries Co., 205 North Michigan Ave., Chicago, Ill.
- '23 Hirsheimer, Louis C. 501 North Third St., La Crosse, Wis.
- '13 Hoffses, G. Raymond Berkshire Fish Hatchery, Great Barrington, Mass.
- '23 Hogan, Joseph R. U. S. Bureau of Fisheries, Gloucester, Mass.
- '24 Hoglund, Iver State Fish Hatchery, Emigrant, Montana.
- '19 Holland, R. P. 45 West 45th St., New York City.
- '24 Holmes, John E. 808 Eldridge Ave., West Collingswood, N. J.
- '22 Holmes, William W. Department of Conservation, New Orleans, La.
- '20 Hoofnagle, G. W. U. S. Bureau of Fisheries, McAllister, Montana.
- '24 Horst, Louis Sunderland, Mass.
- '15 Hovden, K. David & Ocean Ave., Monterey, Cal.
- '18 Howell, G. C. L. Care of H. S. King Co., 9 Pall Mall, London, S. W., England.
- '23 Howley, Thomas 71 East 128th St., New York City, N. Y.
- '23 Hoxie, F. D. American Fish Culture Co., Carolina, R. I.
- '23 Hubbard, Harry E. New Hampton, N. H.
- '00 Hubbard, Waldo F. U. S. Bureau of Fisheries, Nashua, N. Y.
- '20 Hubbs, Carl L. 1201 Fair Oaks Parkway, Ann Harbor, Mich.
- '24 Hubby, T. E. 2900 Sanger Ave., Waco, Texas.
- '16 '24 Huderle, John State Fish Hatchery, Detroit, Minn.
- '13 Huntsman, Dr. A. G. University of Toronto, Toronto, Canada.
- '10 Hussakof, Dr. Louis 1537 50th St., Brooklyn, N. Y.
- '24 Ingraham, Henry A. 165 Broadway, N. Y. City.
- '24 Ilsley, C. W. St. Walberg, Saskatchewan, Canada.
- '18 Jackson, Ralph C. Seven Pines Brook Trout Preserve, Lewis, Wis.
- '24 Jacobs, J. S. 115 Summer St., Springfield, Vt.
- '23 James, Milton C. U. S. Bureau of Fisheries, Washington, D. C.
- '95 Jennings, G. E. "Fishing Gazette", 465 Central Park West, New York City, N. Y.
- '17 Jensen, Harold State Fish Hatchery, St. Peter, Minn.
- '16 Johnson, A. S. 300 Exchange Bldg., Duluth, Minn.
- '23 Johnson, E. D. State Fish Hatchery, Cody, Wyo.
- '13 Jones, Col. E. Lester U. S. Coast & Geodetic Survey, Washington, D. C.
- '08 Jones, Thos. S. Louisville, Ky.
- '22 Judd, E. T. Game & Fish Commissioner, Cando, N. D.
- '23 Jurash, Stephen East River, Conn.
- '18 Kauffman, R. M. "The Star", Washington, D. C.
- '14 Kavanaugh, W. P. Scheurman St., Bay City, Mich.
- '05 Keesecker, A. G. U. S. Bureau of Fisheries, Erwin, Tenn.
- '99 Keil, W. M. Department of Fish & Game, Boise, Idaho.
- '12 Kemmerick, Joseph U. S. Bureau of Fisheries, Birdsvew, Wash.
- '15 Kendall, F. P. P. O. Box 4062, Portland, Ore.
- '15 Kendall, Neal P. O. Box 4062, Portland, Ore.
- '02 Kendall, Dr. William C. U. S. Bureau of Fisheries, Washington, D. C.
- '04 Kent, Edwin C. 19 Liberty St., New York City, N. Y.
- '23 Kienbusch, C. O. 12 East 74th St., New York City, N. Y.
- '13 Kinney, M. J. 1005 Yeon Bldg., Portland, Ore.
- '04 Kisterbock, Josiah, Jr. 401 South 47th St., Philadelphia, Penna.
- '24 Kitson, James A. 506 State House, Boston, Mass.
- '04 Kittredge, Benjamin R. Carmel, N. Y.
- '24 Klancke, A. C. State Game and Fish Department, St. Paul, Minn.
- '24 Knight, Prof. A. P. Alice Street, Kingston, Ontario, Canada.
- '13 Knight, H. J. Alaska Packers Assoc., 111 California St., San Francisco, Cal.

- '23 Kopplin, Phil. 905 North Euclid Ave., St. Louis, Mo.
- '18 Krippendorf, Carl H. Sagamore & New Sts., Cincinnati, Ohio.
- '22 Laird, James A. South Side Sportsman's Club of Long Island, Oakdale, N. Y.
- '03 Lambson, G. H. Fish & Game Commission, Sisson, Cal.
- '16 Landry, D. J. Lake Charles, La.
- '21 Lauerman, Frank J. Marinette, Wis.
- '23 Lavery, P. J. Knox, Indiana.
- '17 Lawyer, George A. U. S. Biological Survey, Washington, D. C.
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